10.5005/jp-journals-10019-1204

RESEARCH ARTICLE

Evaluation of Flexural Modulus of Flexible Denture Base Material kept in Water, Denture Cleanser, Artificial Saliva, and Open Air for Different Time Intervals: An *in vitro* Study

[1]Swapnil Parlani, [2]Benaiffer Agarwal, [3]Anurag Malaiya, [4]Swati Singh, [5]Sunil K Mishra

ABSTRACT

Aim: This was an *in vitro* study done to evaluate the change in flexural modulus of flexible denture base material kept in water, denture cleanser, artificial saliva, and open air for different time intervals.

Materials and methods: The experimental design included four main groups, with each group having three subgroups. A total of 120 specimens were fabricated with each group containing 30 specimens; these four groups, based on duration in the storage condition, were further subdivided into three groups. Group A1: 15 days, group A2: 30 days, and group A3: 60 days.

Results: Flexural modulus of flexible denture in 15 days was found to be highest with denture-cleansing tablet (1246.52 ± 8.69 MPa) and lowest in water (1170.54 ± 7.35 MPa). Flexural modulus of flexible denture in 30 days was found to be highest with open air (1282.94 ± 8.35 MPa) and lowest in denture-cleansing tablet (1145.60 ± 5.34 MPa). Flexural modulus of flexible denture in 60 days was found to be highest with open air (1360.34 ± 8.02 MPa) and lowest in denture-cleansing tablet (1120.43 ± 6.34 MPa).

Conclusion: According to our study, flexibility of nylon denture base material decreases when kept in open air and water for prolonged period. Initially, flexibility of nylon denture base material increases in denture-cleansing tablet and in artificial saliva, and later flexibility decreased in the first month, then there was not much effect. The best medium for storage of flexible denture was found to be artificial saliva.

Keywords: Artificial saliva, Denture cleanser, Flexural modulus, Polyamide, Polymethyl methacrylate.

How to cite this article: Parlani S, Agarwal B, Malaiya A, Singh S, Mishra SK. Evaluation of Flexural Modulus of Flexible Denture Base Material kept in Water, Denture Cleanser, Artificial Saliva, and Open Air for Different Time Intervals: An *in vitro* Study. Int J Prosthodont Restor Dent 2018;8(2):54-58.

Source of support: Nil

Conflict of interest: None

[1,2,5]Professor, [3,4]Postgraduate Student

[1-5]Department of Prosthodontics and Crown and Bridge, People's College of Dental Sciences & Research Centre, Bhopal, Madhya Pradesh, India

Corresponding Author: Anurag Malaiya, Postgraduate Student, Department of Prosthodontics and Crown and Bridge People's College of Dental Sciences & Research Centre, Bhopal Madhya Pradesh, India, e-mail: malaiya.anurag@gmail.com

INTRODUCTION

In the majority of population, the loss of teeth is a matter of concern and their replacement is done by removable or fixed artificial substitutes. Removable prostheses are fabricated using polymethylmethacrylate (PMMA) resin and nylon-based plastic (polyamide).[1]

Due to various advantages, such as low toxicity, adequate strength, low water sorption and solubility, excellent esthetic value, easy to repair, and a simple processing technique, PMMA has been the most popular material used for denture fabrication since its introduction in 1937. Regardless, it has issues of polymerization shrinkage, weak flexural strength, lower impact strength, and low fatigue resistance.[2] In this manner, improvised thermoplastic nylon can be a useful alternative to PMMA in extraordinary conditions where higher flexibility, higher resistance to flexural fatigue, and higher impact strength are required.[3]

Also, it was asserted that nylon materials have different focal point advantages including higher elasticity than common heat polymerizing resins, toxicological safety for patients with monomer allergy and metal allergy, and use of heat molding instead of chemical polymerization to control the polymerization shrinkage and its related deformation.[2]

The denture of patient is exposed to different conditions in the oral cavity. These agents may affect the mechanical property of flexible denture base material. There might be changes in the modulus of elasticity of flexible denture base when they are exposed to denture cleansers, artificial saliva and kept in open air (not immersed in water), but it has not been studied and investigated till now.[4] So, this study aims to evaluate the effect of different agents on the flexural strength and flexural modulus of thermoplastic nylon denture base material for different time durations (15, 30, and 60 days).

MATERIALS AND METHODS

The study was undertaken in the Department of Prosthodontics with supporting technical assistance from Central Institute of Plastics Engineering and Technology and Centre for Scientific Research and Development.

Table 1: Specimen distribution among groups

Group	*Category*	*Number of samples*
I	Denture cleanser (Clinsodent)	30
II	Artificial saliva	30
III	Open air	30
IV	Water	30

The experimental design included four main groups, with each group having three subgroups. A total of 120 samples were fabricated with each group containing 30 samples (Table 1); further, based on duration in the storage condition, these four groups were further subdivided into three groups. Group A1: 15 days, group A2: 30 days, and group A3: 60 days (Flow Chart 1).

SAMPLE FABRICATION AND STORAGE

For standardization, the rectangular metal dies were made for the fabrication of sample with dimensions of 65 × 10 × 2.5 mm according to the American Dental Association specification number 12 for denture base polymers.

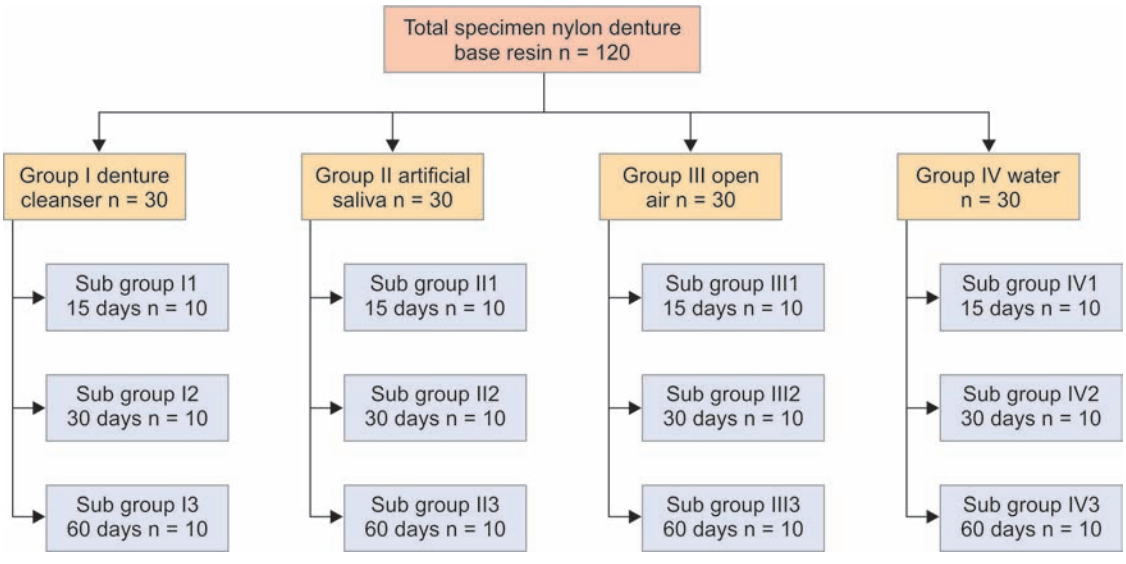
The rectangular samples were fabricated using nylon co-polyamide resin (Lucitone FRS Dental Resin, Dentsply India Pvt. Ltd, Haryana, India) with injection molding technique (Dentsply, Milford, USA). The specimens were stored for 15, 30, and 60 days (Fig. 1) in different storage media.

Flexural modulus of flexible denture base material was calculated using Universal Instron testing machine (Instron Corp., Canton, MA) at a crosshead speed of 1.8 mm/min (Fig. 2). Thickness and width of each sample were measured with the help of digital Vernier caliper. The samples were placed on jigs that were 50 mm apart (L) and then loaded at the center until fracture occurred. The peak load (fracture load) was recorded and tabulated as:

$S = 3PL/2bd^2$

S = Flexural strength (N/mm^2),

Flow Chart 1: Specimen distribution among groups



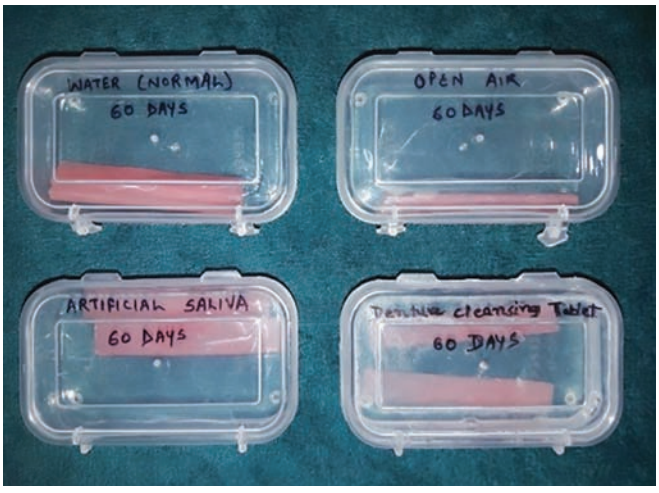


Fig. 1: Sixty-day sample kept in different solutions

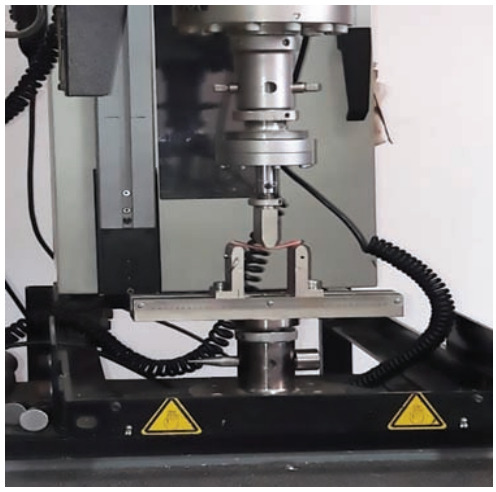


Fig. 2: Flexural strength testing using universal testing machine

P = Load at fracture,
L = Distance between jig support,
b = Specimen width,
d = Specimen thickness.

Statistical Analysis

Data were entered in Microsoft Excel 2016 for Windows. Mean, standard deviation (SD), minimum, and maximum values of flexural modulus of flexible denture base material in different agents at different time intervals were calculated.

Shapiro–Wilk test, two-way analysis of variance (ANOVA) and least significant difference (LSD) *post hoc* test was applied for pair-wise comparison. Data analysis was performed using version 21.0 of the Statistical Package for the Social Sciences, (IBM Corporation, Armonk, New York, USA).

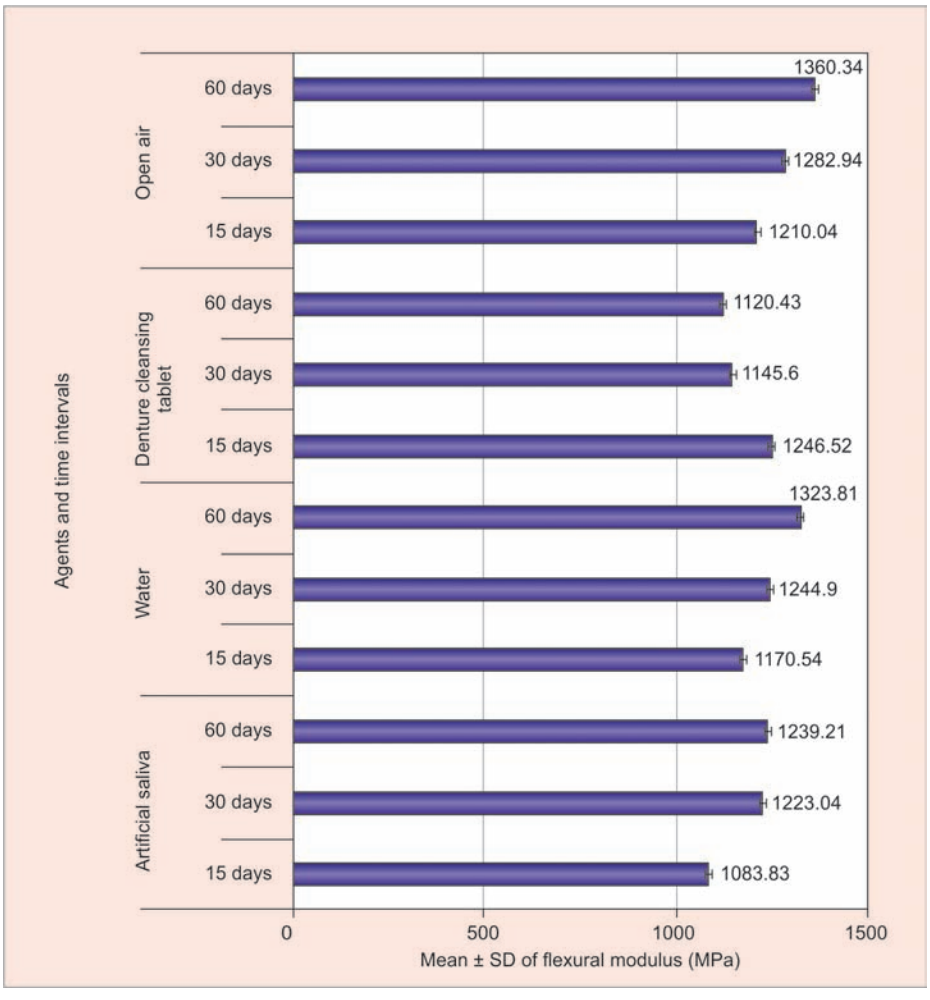
RESULTS

The mean flexural modulus among groups I, II, III, and IV at three different time periods is presented in Table 2 and Graph 1.

Table 2: Two way ANOVA for comparison of flexural modulus of flexible denture base material in different agents at different time intervals

	Flexural modulus at different time intervals (MPa)							
	15 days		*30 days*		*60 days*			
Agents	*Mean ± SD*	*Min–Max*	*Mean ± SD*	*Min–Max*	*Mean ± SD*	*Min–Max*	*F ratio*	*p-value*
Artificial saliva	1083.83 ± 6.65	1076.03–1094.05	1223.04 ± 7.47	1213.86–1233.95	1239.21 ± 7.11	1227.31–1246.49	994.849	<0.001
Water	1170.54 ± 7.35	1159.99–1181.10	1244.90 ± 5.60	1236.40–1252.40	1323.81 ± 9.52	1309.72–1337.91		
Denture-cleansing tablet	1246.52 ± 8.69	1233.19–1259.90	1145.60 ± 5.34	1140.07–1158.43	1120.43 ± 6.34	1110.43–1128.98		
Open air	1210.04 ± 7.14	1200.09–1219.98	1282.94 ± 8.35	1269.39–1296.49	1360.34 ± 8.02	1345.73–1374.95		

p-value < 0.05 was considered statistically significant



Graph 1: Comparison of flexural modulus of flexible denture base material in different agents at different time intervals

Table 3: Pairwise comparison via LSD *post hoc* test

Days	*Medium*
15 days	Denture-cleansing tablet > Open air > Water > Artificial saliva
30 days	Open air > Water > Artificial saliva > Denture-cleansing tablet
60 days	Open air > Water > Artificial saliva > Denture-cleansing tablet ter

Flexural modulus of flexible denture in 15 days was found to be highest with denture-cleansing tablet (1246.52 ± 8.69) and lowest in artificial saliva (1083.83 ± 6.65). Flexural modulus of flexible denture in 30 days was found to be highest with open air (1282.94 ± 8.35) and lowest in denture-cleansing tablet (1145.60 ± 5.34). Flexural modulus of flexible denture in 60 days was found to be highest with open air (1360.34 ± 8.02) and lowest in denture-cleansing tablet (1120.43 ± 6.34).

Shapiro–Wilk test showed that flexural modulus values followed normal distribution. The interaction effect of agents and time intervals was significant on flexural modulus [$F(6,108) = 994.849$, $p < 0.001$]. The LSD *post hoc* test (Table 3) done for pair-wise comparison showed best mean of flexural modulus for denture-cleansing tablet in 15 days followed by open air, water, and least is for artificial saliva. In 30 and 60 days best mean of flexural modulus was found for open air, water, artificial saliva and least was for denture-cleansing tablets.

DISCUSSION

The purpose of this study was to know the effect of different storage media on the mechanical properties of flexible denture base material. When not disinfected, nylon exhibited the lowest flexural modulus of 1714 MPa, while the disinfected specimens had a value of 1937 MPa. The low flexural modulus exhibited by nylon means that it is less rigid than the conventional PMMA polymers. This is not surprising, as it is indicated in certain clinical situations where flexibility is desired.[5]

Nylon is advanced as a denture base material in the light of the premise of its flexibility, which enables it to engage certain degree of undercuts for retention without these undercuts being blocked.[6] At the same time, nylon has also been claimed to be a good alternative in denture patients who have sensitivity or allergy to methyl methacrylate monomer. Polyamide did not have aromatic ring in the structure. In this manner, it is theorized that the infiltration of water particles into the polymer structure impacted the flexural modulus.[7]

Polyamide had a tendency to have characteristically high water sorption values. This phenomenon is clarified by the water absorption happening among the molecular chains because of the high hydrophilicity of the numerous amide bonds forming the main chains of the polyamide resin.[8] Water sorption relies upon the level of hydrophobicity and porosity of the material. In clinical use, resin denture base materials are susceptible to water sorption and solubility when immersed in an aqueous medium, such as saliva, nasal secretion, and water or cleansing agents. When immersed in such solutions, plasticizers and other soluble components may leach out over extended periods while water or saliva is being absorbed. The loss of plasticizer may cause a decreased percentage of elongation and increased hardness values. Absorbed water has a detrimental effect on the physical and mechanical properties of the resin denture base.[9]

According to our study, flexibility of nylon denture base material decreases when kept in open air and water for prolonged period. In the study done by Takabayashi,[10] water sorption of two of the tried polyamide materials (Valplast and Flexite Supreme) met International Organization for Standardization standards (32 gm/mm^3); yet, Lucitone FRS uncovered the most astounding water sorption because of the more prominent level of hydrophilic attributes supported by the contact edge estimations. It is suspected that the higher the amide aggregate focus, the more noteworthy the water sorption. In this way, it has been proposed that the amide group concentration, in the polyamide type denture base materials, could be acclimated to a level as low as that in popular industrial materials, such as nylon 6 or 66.

Denture cleansers are most commonly utilized by denture wearers for cleaning, but cleanser may have harmful effect on the plastic or metal component of the denture, so the dental practitioner must be able to recommend a denture cleanser that is effective, non-deteriorative to denture base material, and safe for persistent utilize.[11] According to our study, flexibility of nylon denture base material increases in denture-cleansing tablet. Result of the study shows that highest flexural modulus was at 15 days and lowest at 60 days. There was an adverse effect of the prepared denture cleansers which contain isopropyl alcohol on indentation hardness and flexural strength; it decreased both these properties and so, it is advised not to use it with nylon denture because it decreased its flexibility on prolonged immersion[12]. Commercially available Lacalut dent, which is an oxygenating denture cleanser, had no adverse effects on polymers used, so it is safe to use.[11] According to the result, flexibility in artificial saliva decreased in first month, then there was not much effect, and so, it can be used as storage medium for nylon denture base, as flexibility of material is maintained for longevity of prosthesis.

CONCLUSION

Flexible denture bases are mainly indicated in clinical cases with areas in oral cavity having severe hard and soft

tissue undercuts. In such areas, flexibility of denture bases is a prime requisite for easy placement and removal of denture bases. So, to maintain the flexibility of prosthesis, a suitable storage medium is required. For storage we use open air, water, denture cleanser, and artificial saliva. The result of present study shows that flexibility in artificial saliva decreased in the first month, then there was not much effect, so it can be used by the patient as storage medium for nylon denture base, as flexibility of material is maintained for longevity of prosthesis.

REFERENCES

1. Shah VR, Shah DN, Chauhan CJ, Doshi PJ, Kumar A. Evaluation of flexural strength and color stability of different denture base materials including flexible material after using different denture cleansers. J Indian Prosthodont Soc 2015 Oct-Dec; 15(4):367-373.
2. Vojdani M, Giti R. Polyamide as a denture base material: a literature review. J Dent (Shiraz) 2015 Mar;16(Suppl 1):1-9.
3. Kohli S, Bhatia S. Polyamides in dentistry. Int J Sci Study 2013 Apr-Jun;1(1):20-25.
4. Peracini A, Davi LR, de Queiroz Ribeiro N, de Souza RF, Lovato da Silva CH, Paranhos HF. Effect of denture cleansers on physical properties of heat-polymerized acrylic resin. J Prosthodont Res 2010 Apr;54(2):78-83.
5. Ali IL, Yunus N, Abu-Hassan MI. Hardness, flexural strength, and flexural modulus comparisons of three differently cured denture base systems. J Prosthodont 2008 Oct;17(7):545-549.
6. John J, Gangadhar SA, Shah I. Flexural strength of heat-polymerized polymethyl methacrylate denture resin reinforced with glass, aramid, or nylon fibers. J Prosthet Dent 2001 Oct;86(4):424-427.
7. Galav A, Deogade SC, Mantri S, Sumathi K, Galav S. Effect of water storage on the flexural strength of heat-cured denture base resin reinforced with stick (s) glass fibers. Contemp Clin Dent 2017 Apr-Jun;8(2):264-271.
8. Nguyen LG, Kopperud HM, Øilo M. Water sorption and solubility of polyamide denture base materials. Acta Biomater Odontol Scand 2017 May;3(1):47-52.
9. Barsby MJ. A denture base resin with low water absorption. J Dent 1992 Aug;20(4):240-244.
10. Takabayashi Y. Characteristics of denture thermoplastic resins for non-metal clasp dentures. Dent Mater J 2010 Aug;29(4): 353-361.
11. Salman M, Saleem S. Effect of different denture cleanser solutions on some mechanical and physical properties of nylon and acrylic denture base materials. J Baghdad Coll Dent 2011 Jan;23:19-24.
12. Porwal A, Khandelwal M, Punia V, Sharma V. Effect of denture cleansers on color stability, surface roughness, and hardness of different denture base resins. J Indian Prosthodont Soc 2017 Jan-Mar;17(1):61-67.