Original Article

Comparative Evaluation of Mechanical, Optical and Surface Properties of Four Commercially Available Flexible Denture Base Materials on Water Absorption- An In Vitro Study

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ABSTRACT

Aim: This study is oriented to evaluate the impact of water absorption on mechanical, optical, and surface properties of four commercially available flexible denture base resins. **Materials And Methods:** A total of 120 samples were prepared, with 24 samples for each of four resin types(Valplast, Lucitone FRS, Bre-Flex, and De-Flex) and 24 controls. Specimens followed ADA specification number 12 for flexural strength, surface hardness, surface roughness, and colour stability tests. Resin polymerization methods included auto-mix syringe injection for thermoplastics and compression moulding for PMMA. **Results:** Valplast exhibited the highest flexural strength consistently over time, followed by Lucitone FRS, PMMA, and De-Flex, with Bre-Flex showing the lowest resistance to bending. Valplast also maintained superior surface hardness compared to Lucitone FRS, which degraded over time. Valplast showed minimal surface roughness, enhancing aesthetics and comfort. Lucitone FRS displayed declining surface hardness, potentially impacting long-term durability with denture cleaners. Bre-Flex demonstrated exceptional colour stability, while Valplast also retained colour well. In contrast, De-Flex showed significant colour changes, raising durability concerns. **Conclusion:** Valplast demonstrated superior flexural strength, surface hardness, and surface roughness characteristics, making it highly suitable for long-term denture use. Bre-Flex excelled in colour stability but showed lower mechanical properties. Lucitone FRS exhibited good initial properties but suffered from reduced surface hardness over time. De-Flex's colour instability raises durability concerns. These findings highlight Valplast's overall favourable performance across multiple parameters crucial for denture base materials, emphasizing its potential for enhancing denture longevity and patient satisfaction.

Key-Words: Flexible Denture Base Material, Valplast, Lucitone FRS, Bre-Flex, De-Flex, Colour Stability, Flexural Strength

INTRODUCTION

Edentulism significantly impacts an individual's quality of life by impairing chewing, speaking, and facial aesthetics. The prevalence of complete edentulism varies globally, with higher rates in countries like India, Mexico, and Russia. Factors contributing to tooth loss include smoking, poor diet, and inadequate dental care.[1] Denture base materials have evolved to improve functionality, aesthetics, and patient satisfaction. Polymethyl methacrylate (PMMA) has been the traditional choice for denture bases due to its ease of processing and cost-effectiveness[2], but it has limitations such as volumetric shrinkage, water absorption, and low fracture resistance. Newer materials like flexible thermoplastic resins (e.g., Valplast and Bre-flex), composite resins, and nanocomposites offer improved properties, such as better flexural strength, surface hardness, and colour stability. Flexible denture materials like Valplast provide enhanced comfort and durability, while composite resins reinforced with fibers offer increased fracture resistance and longevity. Maintaining denture hygiene is crucial to prevent infections and ensure the longevity of dentures. Chemical denture cleansers can affect the physical properties of denture materials, necessitating careful selection to avoid compromising the denture's integrity[3]. This study aims to evaluate and compare various properties of different denture base materials, focusing on the impact of denture cleansers on colour stability, surface roughness, hardness, and flexural strength. The research seeks to guide the selection of denture base materials and denture cleansers to optimize denture performance and longevity.

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MATERIALS AND METHODS

A total of 120 samples, comprising 24 samples of each four types of commercially available flexible denture base materials and 24 samples for a control group,

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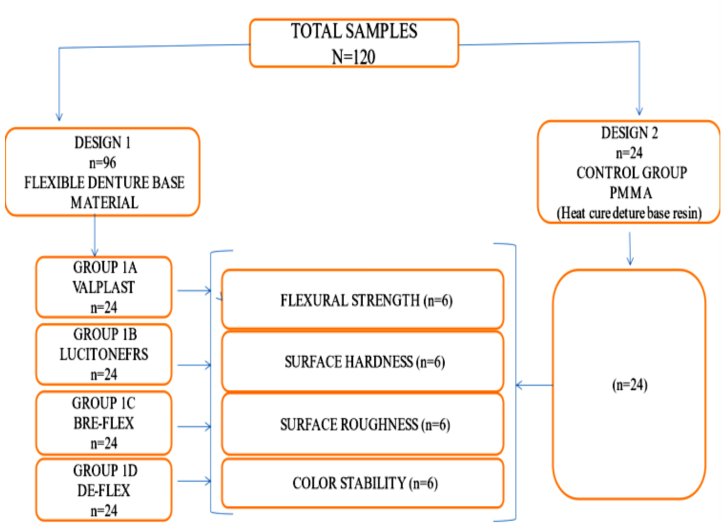
were prepared and tested for flexural strength, surface properties, and colour stability. Groups were as, Group A: Valplast (Novoblast, USA), Group B: Lucitone FRS (Dentsply, Germany), Group C: Bre-flex (Bredent, Germany), Group D: De-flex (De-flex, United Kingdom)and a control group: PMMA heat cure denture base resin. [Figure-1] A total of 96 samples were prepared using injection moulding for the flexible denture base resins, following ADA specification no. 12, and 24 samples were prepared using compression moulding for the PMMA heat cure resin.

Sample Size Selection

The size of the sample was determined using a statistical method known as Analysis of Variance, or ANOVA, in order to conduct comparisons among k means using a One-way ANOVA Pair wise, 2-Sided Equality approach. In broader terms, if we have k groups, there will be a total of K ≡ (k/2) = k(k−1)/2 potential pairwise comparisons[3]. When we examine τ ≤K of these pairwise comparisons, we are testing hypotheses of the form:H0: μA=μB;H1: μA≠μB where μA and μB denote the means of two of the k groups, referred to as groups 'A' and 'B'. The necessary sample size for each of these τ comparisons will be calculated, andthe overall sample size required is determined by the largest among these. In the following formula, n represents the sample size in any one of these τ comparisons, meaning there are n/2 individuals in group 'A' and n/2 individuals in group 'B'.

SAMPLES FLOW CHART



Surface treatment with 3.8% Sodium Perborate (w/v) denture chemical cleanser to check flexural strength, surface hardness, surface roughness and colour stability.

0 Day (N=120)>1 Month (N=40)>3 Months (N=40)>6 Months (N=40)

For Testing of Samples in 1 Month, 3 Months, 6 Months-(n=2)

Preparation of Flexible Denture Base Material Samples

A master mold from a stainless-steel block (65 x 10 x 3 mm and 1.5 mm x 50 mm) was used, in accordance in accordance with ADA specification no. 12. The process involved flask preparation and heating and injecting material. The lower flask section was coated with petroleum jelly and positioned flat. Type 4 gypsum was poured, followed by the upper flask section, forming the first pour. The flask was preheated for 15 minutes, silicone spray was applied to a filled cartridge, which was placed in the furnace. Post heating for 17 minutes, the flask was assembled and injected. The assembly was cooled, and the samples were refined and polished using acrylic techniques. [Figure-2]

Preparation of PMMA Heat Cure Denture Base Resin Samples

Wax patterns were created using moulds of the specified dimensions. The polymerization process involved, wax Pattern investment, boil-out and cleaning, and acrylization. PMMA resin was mixed, kneaded, placed in the mold cavity, and pressurized. The curing cycle included an 8-hour water bath at 74°C followed by 1 hour at 100°C. The flask was cooled, and the specimens were finished and polished using acrylic burs, sandpaper, rubber points, and pumice. [Figure-3]

Testing and Cleansing Protocol

The samples were subjected to daily cleaning with a 3.8% sodium perborate solution for 10 minutes, rinsed, and stored at room temperature for six months. Physical, surface, and optical properties were evaluated at 1-month, 3-month, and 6-month intervals using, a universal testing machine, a Vickers hardness tester (for surface hardness), a surface profilometer (for surface roughness), and a spectrophotometer (for colour stability). [Figure-2,4] It aimed to assess and compare the performance of flexible denture base materials and PMMA over time, ensuring thorough evaluation and reliable results.

Fig 1: Materials used for fabrication of samples

Fig 2: Dies used for making samples and Equipments used for testing of samples

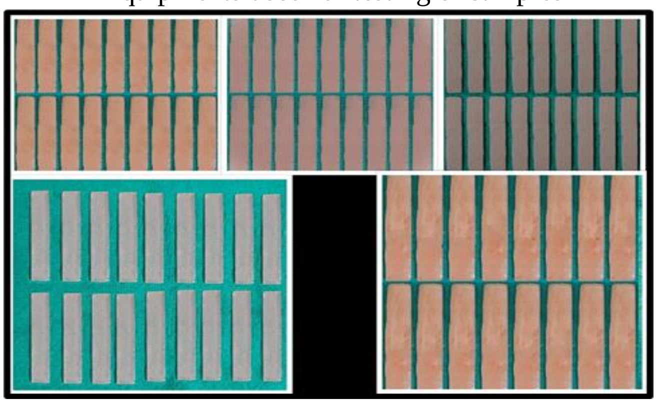


Fig 3: Fabricated samples for testing of mechanical and surface properties

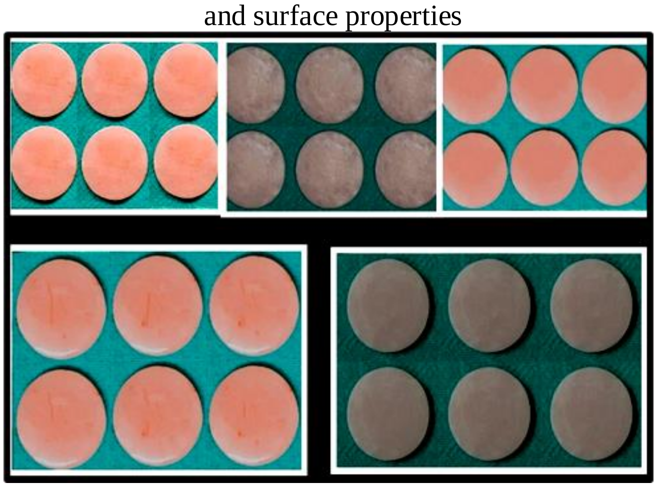


Fig 4: Fabricated samples for testing of optical property

RESULTS

Flexural strength was evaluated across five material groups at 1, 3, and 6-month intervals. Valplast consistently exhibited the highest flexural strength at each interval, followed by Lucitone FRS, PMMA, De Flex, and Bre Flex, which consistently showed the lowest strength. Significant differences were observed among all five material groups at each time point, highlighting Valplast's superior mechanical performance over time compared to the other materials. [Table-1]

Surface hardness was assessed across five material groups at 1, 3, and 6-month intervals. After 1 month, Valplast exhibited the highest surface hardness, followed by De-flex, PMMA, Bre-Flex, and Lucitone FRS, which showed the lowest. Significant differences were noted among all five material groups. After 3 months, Valplast maintained the highest surface hardness, followed by PMMA, Bre-Flex, De-flex, and Lucitone FRS, with significant differences observed among the groups. Similarly, at 6 months, Valplast retained the highest surface hardness, followed by Bre-Flex, PMMA, De-flex, and Lucitone FRS, with significant differences noted among all material groups. [Table-2]

Surface roughness was assessed across five material groups at 1, 3, and 6-month intervals. After 1 month, the lowest surface roughness was observed in Valplast, followed by De-flex, Bre-flex, Lucitone FRS, and the highest in PMMA. A significant difference was noted among the five materials. This trend persisted at 3 and 6 months, with Valplast consistently having the least roughness and PMMA the most, with significant differences among all groups. [Table-3] After 1 month, the least colour change was observed in Bre-flex, followed by Valplast, Lucitone FRS, PMMA, and the highest in De-flex, with significant differences among the materials. This pattern remained consistent at 3 months. After 6 months, Bre Flex still had the least colour change, followed by Lucitone FRS, Valplast, PMMA, and the highest in De-flex, with significant differences among all groups throughout. [Table-4]

Table: 1

Group	1 Month		3 Months		6 Months	
	Mean	SD	Mean	SD	Mean	SD
Valplast	146.01	0.58	144.50	0.42	138.20	0.85
Lucitone FRS	140.57	0.10	137.72	0.79	130.11	0.16
Bre-Flex	102.85	0.03	100.72	0.08	96.60	0.28
De-Flex	120.53	0.18	116.20	0.06	112.17	0.09
PMMA	129.86	0.47	125.27	0.49	122.03	0.49
p-value	<0.001*		<0.001*		<0.001*	
One-way ANOVA test; * indicates a significant difference at p≤0.0						

Table: 2

Group	1 Month		3 Months		6 Months	
	Mean	SD	Mean	SD	Mean	SD
Valplast	20.10	0.03	18.90	0.28	17.75	0.21
Lucitone FRS	16.45	0.21	15.70	0.14	14.65	0.07
Bre-Flex	17.20	0.14	16.35	0.35	15.70	0.14
De-Flex	18.25	0.21	16.10	0.14	14.95	0.21
PMMA	17.25	0.07	16.65	0.07	15.55	0.07
p-value	<0.001*		<0.001*		<0.001*	

Table: 3

Group	1 Month		3 Months		6 Months	
	Mean	SD	Mean	SD	Mean	SD
Valplast	0.41	0.01	0.42	0.03	0.47	0.01
Lucitone FRS	0.53	0.01	0.57	0.01	0.63	0.01
Bre-Flex	0.47	0.01	0.51	0.01	0.57	0.01
De-Flex	0.42	0.01	0.45	0.01	0.49	0.01
PMMA	1.16	0.01	1.21	0.01	1.27	0.01
p-value	<0.001*		<0.001*		<0.001*	

Table: 4

Group	1 Month		3 Months		6 Months	
	Mean	SD	Mean	SD	Mean	SD
Valplast	0.92	0.01	1.06	0.01	1.26	0.01
Lucitone FRS	1.11	0.01	1.17	0.01	1.23	0.01
Bre-Flex	0.60	0.03	0.75	0.01	0.85	0.01
De-Flex	1.50	0.03	1.65	0.01	1.72	0.03
PMMA	1.30	0.00	1.40	0.07	1.60	0.07
p-value	<0.001*		<0.001*		<0.001*	

DISCUSSION

Polymethyl-methacrylate (PMMA) is known for its rigidity, making it unsuitable for severe undercuts in denture applications. Studies show that adding carbon fibres to PMMA increases porosity and surface imperfections, compromising strength. Alternative materials with better flexibility[4], such as thermoplastic materials (polyacetal or polyamide nylon), offer benefits like stability, resistance to heat, deformation, solvents, and wear, making them suitable for undercut areas. The study evaluated the long-term effects of a 3.8% sodium perborate denture cleanser on the flexural strength of four commercially available flexible denture base resins over six months[5]. Valplast exhibited the highest flexural strength consistently, followed by Lucitone FRS, PMMA, and De-flex, with Bre-flex showing the lowest. Flexural strength decreased over time for all materials, indicating that the cleaner may have a deteriorating effect. PMMA showed significant strength loss after three months, highlighting its vulnerability[6,7]. Valplast maintained superior surface hardness over time, suggesting high durability against the sodium perborate cleaner. In contrast, Lucitone FRS showed the lowest surface hardness, indicating susceptibility to deterioration. Changes in surface hardness over time varied among materials, with Valplast showing minimal changes and others like De-flex, PMMA, and Bre-flex exhibiting variable hardness trends[8,5]. Valplast consistently demonstrated the lowest surface roughness, indicating its ability to maintain a smooth surface despite exposure to cleaning agents[9,10]. PMMA showed the highest roughness, highlighting its limited capacity to maintain a smooth surface over time. The findings emphasize the importance of material selection for long-term denture maintenance[11]. The study assessed colour changes over six months. Bre-flex exhibited the least colour change, indicating excellent colour stability, while De-flex showed the greatest discolouration. Valplast and Lucitone FRS displayed moderate colour stability, with PMMA showing significant colour change[12]. The temporal analysis revealed that some materials had improved colour stability over time, while others deteriorated. These findings have significant clinical implications. Valplast's high flexural strength, surface hardness, low roughness, and colour stability make it a suitable choice for long-term denture use[13]. In contrast, PMMA's vulnerability to strength loss, surface roughness, and colour change suggests it may not be ideal for flexible denture bases[14]. Dental professionals should consider these factors when recommending materials for dentures, ensuring a balance between favorable properties and long-term durability. The study's findings align with previous research indicating that nylon-based materials like Valplast offer superior flexibility and resistance compared to PMMA[15,13]. Studies have shown that thermoplastic materials generally exhibit better long-term performance in terms of mechanical properties, surface characteristics, and colour stability[16,17]. The results also highlight the impact of denture cleansers on material properties, underscoring the need for careful selection of both materials and cleaning agents to ensure optimal denture longevity and performance[18]. These findings have significant clinical implications for individuals who wear dentures and for dental professionals. Comprehending the precise behavior of materials when exposed to cleansers over a lengthy period of time might help in choosing suitable materials according to the requirements of patients and maintenance procedures. When advising patients on cleaning routines, clinicians should take into account the balance between the favorable characteristics of denture materials and their vulnerability to deterioration over time.

CONCLUSION

The study concludes that Valplast is a promising material for dentures due to its high flexural strength, surface hardness, low roughness and in aspect of colour stability Bre-flex in superior to others, while PMMA commonly used, shows limitations in these areas, suggesting the need for alternative materials in specific denture applications. The choice of denture materials and cleansers should be tailored to balance durability, esthetics, and patient comfort for long-term satisfaction. In summary, further research on this topic could deepen our understanding of how water absorption affects flexible denture base materials across various dimensions like impact strength, tensile strength, shear strength a paving the way for advancements in dental material science and improved patient outcomes in prosthodontics.

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