

An In Vitro Analysis of Wear Resistance of Commercially Available Acrylic Denture Teeth

Mallika S. Shetty · K. Kamalakanth Shenoy

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Abstract Posterior denture teeth wear faster than the anterior teeth, causing occlusal prematurities and loss of vertical dimension of occlusion. The loss of vertical dimension of occlusion lays more stress on the anterior alveolar ridge, which in turn increases the rate of residual ridge resorption and causes loss of alveolar ridge height in the anterior segment and compromises esthetics. Hence it is important for the clinician to choose acrylic resin teeth with high wear resistance. The objective of the study is to investigate and compare the wear resistance of three different commercially available acrylic resin denture teeth. 60 specimens were tested for wear resistance in terms of loss of weight and loss in volume on a wear and friction monitor for 5,000 cycle wear periods (total of 10,000 cycles) under a 0.20 kg load. Statistical analysis used: The findings were analyzed using one way analysis of variance (ANOVA) and Tukey HSD test. Comparison of weight loss and volume loss between Surana ultradent, Premadent and Dentek showed highly significant difference, Surana ultradent having better wear resistance. Surana ultradent acrylic resin denture had highest wear resistance amongst the three groups of tested samples.

Keywords Acrylic resin teeth · Wear resistance · Cross linking

M. S. Shetty (✉) · K. K. Shenoy
Dept of Prosthodontics, Yenepoya Dental College,
Derlakatte, Mangalore, Karnataka, India
e-mail: dimp19@yahoo.com

M. S. Shetty
Laxmi Nilaya, Near Don Bosco Hall Cross road,
Mangalore 575001, Karnataka, India

Introduction

Denture teeth are made of either Acrylic Resin or porcelain. Acrylic teeth are most widely used and preferred over porcelain teeth due to their wide range of desirable properties. Acrylic resin teeth bond well to denture base resin can be easily ground, recontoured and polished without compromising their properties, have a desirable natural feel, are less prone to fracture, do not abrade opposing natural or artificial tooth, absence of clicking sound and have a natural appearance [1].

However, acrylic resin teeth have a major drawback of low wear resistance. The factors affecting the wear rate include the pressure between the abrading surfaces, the relative speed of movement between the surfaces, the characteristics of the surfaces & the composition of the materials in contact. Wearing away of denture teeth will compromise both the function and the aesthetics of the denture [2].

It has been observed that, in the oral cavity posterior denture teeth wear faster than the anterior teeth, causing occlusal prematurities and loss of vertical dimension of occlusion. The loss of vertical dimension of occlusion lays more stress on the anterior alveolar ridge, which in turn increases the rate of residual ridge resorption and causes loss of alveolar ridge height in the anterior segment and compromises esthetics. Hence it is important for the clinician to choose acrylic resin teeth with high wear resistance [3]. This study is an attempt to compare the wear resistance of acrylic resin teeth manufactured by three different manufacturers.

Objectives of the Study

- To investigate the wear resistance of commercially available acrylic resin denture teeth.

- To compare the wear resistance of three commercially available acrylic resin denture teeth of following brands
 - Surana ultradent® (Newstetic, Columbia)
 - Dentek® (S P Dental, India)
 - Premadent® (India)

Materials and Methods

Materials

- Three brands of semi-anatomic acrylic denture teeth:
 - Surana Ultradent® (Newstetic, Columbia)
 - Premadent® (India)
 - Dentek® (S P Dental, India)
- Split metal mould with a cylindrical space 7 mm in diameter and 35 mm in length for making wax patterns
- Modelling wax (Deepti dental products, Ratnagiri)
- DPI-TT cold cure acrylic resin (Dental products of India)
- Cylindrical grinding machine (HMT)
- Screw gauge
- Electronic balance (Contech CA Series)
- Measuring glass
- Wear testing machine (wear and friction monitor, Ducom 940 rpm)
- Silicone carbide paper (600 grit)
- Water level

The brands of denture teeth used were Surana ultradent® (Newstetic, Columbia), Premadent® (India), Dentek® (S P Dental, India)

Methods

The wear resistance was tested using wear-testing machine (wear and friction monitor, Ducom) (Fig. 1).

Measurement of Density of Teeth

Density can be obtained by weighing the teeth and by measuring the volume of the teeth. The weight of the teeth was obtained by weighing the teeth in an electronic balance (Contech CA Series). The volume of the teeth was obtained by using a measuring glass, which could read up to 0.2 cc accurately. The measuring glass was filled up with water up to 5 cc for initial reading. The tooth was immersed and a



Fig. 1 Wear and friction monitor, Ducom

rise in level of water in the measuring glass was noted for final readings. The difference between initial and final readings gave the volume of the teeth. Density was calculated with the formula:

$$D = M/V$$

where D = Density of teeth; M = Weight of the teeth; V = Volume of the teeth

Preparation of Acrylic Rod

The rod was made from steel split mould with a cylindrical space of 7 mm in diameter and 35 mm in length (Fig. 2). Modelling wax was melted into the mould space to obtain wax rods of the same dimension. These wax rods were invested in Type III dental stone. Type III dental stone was mixed according to the manufacturer's water powder ratio and filled in one half of the complete denture flask. The wax patterns were immersed halfway into the unset dental stone. Once the stone was set, upper half of the flask was filled with stone and the flask was closed under bench press. The flask was then dewaxed and the two halves of the flask were separated. Separating medium was applied in the mold space. Cold-cure acrylic resin was mixed. The acrylic resin was packed into the mold space in the dough



Fig. 2 Steel split mould

stage. After the cold-cure acrylic resin was cured, the acrylic rod was retrieved. In this manner sixty acrylic rods were prepared.

Preparation of the Tooth Specimen

The ridge lap surface of the teeth was made flat and parallel to the occlusal surface using acrylic burs. The teeth were fixed onto the acrylic rods using cold cure acrylic resin. The length of the rod was 35 mm. The specimens were made to an exact size of 6×6 mm using cylindrical grinding machine. This size was selected for convenience sake and to attempt to make a standard size. “The specimen was measured with the help of a screw gauge of 0.1 mm accuracy. A total of sixty specimens, twenty of each brand was prepared, using the first maxillary and mandibular molar teeth (Fig. 3). The teeth specimens together with the rod were then attached to the wear machine with the help of a holder. The occlusal surface of the teeth were reduced to ensure that the specimen would evenly contact the abrading surface during the test.

Wear Procedure

The specimen tooth along with the attached rods were weighed. Weight of each specimen was measured using the electronic balance (Contech CA Series) up to accuracy of 10^{-4} Gm, and volume of the specimen was checked using a measuring glass. The specimen was held stationary on the apparatus with the help of screws. The wear testing procedure was carried out for each specimen under an applied load of 0.20 kg throughout the wear cycle. The specimens were ground with 600 grit silicon carbide paper, which was attached to the surface of the disc on the apparatus (Fig. 4). Each specimen was subjected to 5,000 cycles (5.18 min), after which it was removed from the testing device along with the holder cleansed of all debris and weighed in the electronic balance to weigh the difference in weight before and after 5,000 cycles. Each specimen was then replaced



Fig. 3 Acrylic rods

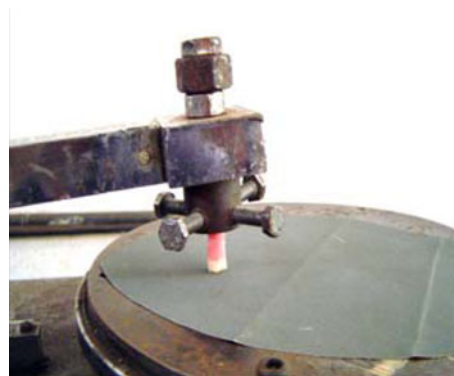


Fig. 4 Grinding of specimens

in the wear-testing device for another 5,000 cycles to complete 10,000 cycles needed for the study. Each specimen was abraded on a fresh silicon carbide paper to avoid clogging with wear debris as a result of multiple passes over the same abrasive surface. After 10,000 cycles the specimens were removed from the holder and the weight and volume was checked to calculate the loss of weight and volume.

Results

The statistical analysis of the results showed the following: (Tables 1, 2, 3, 4, 5 and 6).

- When comparing Group1 with Group 2 the weight and volume before study, the weight loss after 5,000 cycles, the weight loss and volume change after 10,000 cycles, were highly significant.
- When comparing Group1 with Group 3 the weight and volume before study, the weight loss after 5,000 cycles, the weight loss and volume change after 10,000 cycles, were highly significant.
- When comparing Group 2 with Group 3 the weight and volume before study, the weight loss after 5,000 cycles, the weight loss and volume change after 10,000 cycles, were significant.

Discussion

Acrylic resin teeth are the most widely used denture teeth. They have the distinct advantage of adjustability, lack of clicking sounds and good bonding to denture base material when compared to porcelain teeth, but acrylic resin has the disadvantage of poor wear resistance. Posterior teeth are used for chewing and encounter increased load when compared to anterior teeth. Hence posterior acrylic denture teeth tend to wear faster than the anterior acrylic denture

Table 1 Density of the specimen

	Specimen	<i>N</i>	Mean	Standard deviation	<i>F</i>	<i>P</i>
Group1	Surana ultradent	20	0.84895	0.108170		
Group2	Dentek	20	0.81240	0.011838		
Group3	Premadent	20	0.80745	0.008715	92.457	0.001 vhs

vhs very highly significant

Table 2 Weight of the specimen before study

	Specimen	<i>N</i>	Mean	Standard deviation	<i>F</i>	<i>P</i>
Group1	Surana ultradent	20	1.65110	0.025267		
Group2	Dentek	20	1.62285	0.22227		
Group3	Premadent	20	1.60035	0.034543	16.682	0.001 vhs

vhs very highly significant

Table 3 Weight of the specimen after 5,000 cycles

	Specimen	<i>N</i>	Mean	Standard deviation	<i>F</i>	<i>P</i>
Group1	Surana ultradent	20	1.56	0.136164		
Group2	Dentek	20	1.39	0.129901		
Group3	Premadent	20	1.302	0.088873	24.6	0.001 vhs

vhs very highly significant

Table 4 Weight of the specimen after 10,000 cycles

	Specimen	<i>N</i>	Mean	Standard deviation	<i>F</i>	<i>P</i>
Group1	Surana ultradent	20	1.4976	0.112393		
Group2	Dentek	20	1.3791	0.100096		
Group3	Premadent	20	1.2979	0.077818	21.6	0.001 vhs

vhs very highly significant

Table 5 Weight loss in specimen (gm)

	Specimen	<i>N</i>	Mean	Standard deviation	<i>F</i>	<i>P</i>
Group1	Surana ultradent	20	0.154	0.12448		
Group2	Dentek	20	0.244	0.09823		
Group3	Premadent	20	0.302	0.06386	11.55	0.001 vhs

vhs very highly significant

Table 6 Loss of volume (cc)

	Specimen	<i>N</i>	Mean	Standard deviation	<i>F</i>	<i>P</i>
Group1	Surana ultradent	20	0.2685	0.045487		
Group2	Dentek	20	0.3605	0.046530		
Group3	Premadent	20	0.4412	0.048809	67.65	0.001 vhs

vhs very highly significant

teeth. Occlusal wear thus compromises the masticatory efficiency and also reduces the vertical dimension of occlusion [1, 3]. Earlier studies [4–7] have compared wear resistance of acrylic and porcelain denture teeth and acrylic and composite denture teeth. There are very few studies, which compare the wear resistance of different acrylic denture teeth. Coffey et al. in their study tested the wear resistance of conventional acrylic resin and Interpenetrating Polymer Network reinforced acrylic resin teeth and found that Interpenetrating Polymer Network reinforced acrylic resin teeth have higher wear resistance [8]. However, this study did not compare the wear resistance between various brands of cross-linked teeth.

In the present study comparison between various cross-linked teeth were made. This comparison is more valid as cross-linked teeth are the most widely used teeth for denture fabrication today and hence the clinician needs to choose among various cross-linked teeth. The present study was conducted to determine the wear resistance of three commercially available cross-linked acrylic denture teeth. For this, 20 samples of semi-anatomic acrylic denture teeth of each of the three companies (Surana Ultradent® (Newstetic, Columbia), Premadent® (India), Dentek® (S P Dental, India), were selected. The amount of wear was determined by measuring the change in weight and volume of the specimens. The similar method was followed by Verma et al. [1]. For this study “wear and friction monitor” was used, as the instrument allows varying loads to be applied on the test sample.

As the oral cavity displays masticatory cycles ranging 5,000–300,000 cycles in a day, to simulate this condition a wear cycle of 5,000–10,000 was selected. This was in accordance with study done by Hirano et al. [9]. Whitman et al. [3] in their study, on the measurement of wear resistance of acrylic resin denture tooth material, used specimens shaped in the form of disks. Whereas in the

present study, specimens used were acrylic resin denture teeth. Statistical analysis of obtained result showed that in Group 1 (Surana ultradent) (mean density 0.848) the mean decrease in weight and volume was found to be 0.1535 and 0.26853, respectively. In Group 2 (Dentek) (mean density 0.812) the mean decrease in weight and volume was found to be 0.2438 and 0.36045, respectively. In Group 3 (Premadent) (mean density 0.807) the mean decrease in weight and volume was found to be 0.3024 and 0.44115, respectively. The result denotes that Group 1 has improved wear resistance followed by Group 2 and Group 3. Thus, it can be inferred that the wear resistance increases with increase in density of the teeth. The result obtained was also substantiated by the study done by Verma et al. [1], who studied the wear resistance of five brands of commercially available acrylic teeth and concluded that wear resistance of acrylic teeth increase with increase in density.

Ogle et al. [7] evaluated the wear characteristics of the Interpenetrating Polymer Network and unimproved acrylic resin denture teeth. The result showed that the modified resin IPN teeth had significantly more wear resistance than the unimproved acrylic resin denture teeth. This result was similar to that obtained by Coffey et al. wherein the wear resistance of conventional acrylic resin and Interpenetrating Polymer Network reinforced acrylic resin teeth were tested and found that Interpenetrating Polymer Network reinforced acrylic resin teeth have higher wear resistance [8]. The observed variation in the wear resistance of the teeth could be due to the filler particles, which increases the bonding of particles or due to varying density of the cross-linked acrylic resin teeth. The increase in density could be due to the increase in the concentration of the cross-linking agent in the monomer, which influences the density of the acrylic resin. According to cross-linking theory of polymerization [10–12], Cross-linking of the acrylic resin teeth affects the following:

- Greater cross-linking of acrylic resin tooth material causes,
 1. Increase in density
 2. Increase in compressive strength, tensile strength & shear strength
 3. Increase in surface hardness (abrasion resistance)
 4. Increase in glass transition temperature
 5. Decrease in solubility (solvation)
 6. Decrease in sorption

Thus it can be assumed that the addition of cross-linking agent or fillers may influence the wear resistance and other properties of the acrylic resin teeth. The limitation of this study is that the concentration of the cross linking agent is not known, further studies can be done on acrylic resin

teeth in order to assess the various factors responsible for increase in the wear resistance of acrylic resin teeth.

Conclusion

From the present study following conclusions can be drawn.

- When comparing Surana ultradent with Premadent the weight before study, the weight after 5,000 cycles, the weight after 10,000 cycles, the weight loss and the volume loss were highly significant. Surana ultradent has better wear resistance than Premadent.
- When comparing Surana ultradent with Dentek the weight before study, the weight after 5,000 cycles, the weight after 10,000 cycles, the weight loss and the volume loss were highly significant. Surana ultradent has better wear resistance than Dentek.
- When comparing Premadent with Dentek the weight before study, the weight after 5,000 cycles, the weight after 10,000 cycles, the weight loss and the volume loss was significant. Dentek has better wear resistance than Premadent.

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