ORIGINAL RESEARCH

Comparison of Microhardness of Three Different Types of Acrylic Artificial Denture Teeth: An *in vitro* Study

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ABSTRACT

The wear resistance of denture teeth is important for the longevity of removable prostheses of edentulous patients. The ability of denture teeth to maintain maximum intercuspation at centric jaw relation position, masticatory efficiency, the occlusal vertical dimension, and occlusal stability over time may be influenced by this property. Inferior wear resistance of acrylic resin artificial teeth is a significant limitation for complete denture therapy due to its inability to resist parafunctional movements and maintain proper occlusal relationships over time. Therefore acrylic resin teeth have been modified to overcome these disadvantages by the use of cross-linking agents, different monomers, and the addition of fillers.

In the present study microhardness is compared of the different acrylic teeth since it is related to wear resistance and is the most commonly examined mechanical property indicator for synthetic artificial tooth material.

Keywords: Microhardness, Artificial acrylic teeth, Vickers hardness.

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INTRODUCTION

One of the most important physical properties of artificial teeth used in the restoration of the edentulous patient is wear resistance and the ability of these teeth to maintain a stable occlusal relationship overtime. Failure to maintain the same causes loss of masticatory efficiency, faulty tooth relationship and increased horizontal stresses and their associated sequelae. The mechanism of wear in occlusal contact areas of dental restorations is not completely understood. Three basic types of wear have been suggested: frictional wear or the interaction of microscopic irregularities, adhesive wear produced during the shearing of surface irregularities between the two occluding surfaces, and abrasive wear that occurs whenever hard foreign particles are present between the two occluding surfaces.[1] Wear depends on many factors such as neuromuscular forces and movements, lubricants associated with salivary flow and pH, foreign objects, exposure to an abrasive or corrosive atmosphere, patient's habit, diet, poor or excessive hygiene, and the type of restorative material used.[2]

Acrylic resins and porcelains have been used for the fabrication of artificial teeth; however, neither type completely accomplishes the requirements for an ideal prosthetic tooth. Porcelain has been reported to be the most durable material with good color quality and stability. But fracture and detachment from the denture base is frequently observed.[3-5] Among advantages claimed for resin teeth as opposed to porcelain teeth, are less breakage, a reduction of clicking, a better bond between the teeth and the resin base, and the ease of grinding, recontouring, and repolishing.[6] Acrylic resin teeth have been modified to overcome the disadvantage of wear by using cross-linking agents, different monomers, and the addition of fillers.[7] New types of artificial teeth using modified acrylic resin that incorporate cross-linking agents and composite resin containing filler have become increasingly common. A profoundly cross-linked system has the following advantages: color stability, plaque resistance, tissue compatibility, wear resistance, high grinding strength and excellent polishing properties (due to increased thermal resistance). Cross-linking agents also improve strength and crazing resistance. Double cross-linking procedure, eliminates the weak points of conventional polymethacrylate teeth, such as the exposure of uncross-linked polymer beads that detach during grinding. Simultaneously, the double cross-linking process leads to a considerably enhanced resistance to the mechanical wear caused by food, contact with the opposing dentition as well as tooth brushing.

However, cross-linked acrylic resin artificial teeth have been reported to demonstrate lower bond strength to denture base resin when compared to conventional acrylic resin teeth.[8] Therefore, the ridge lap portion of the teeth is expected to be the least cross-linked so as to facilitate bonding to the denture base resin.[7,9]

Hardness is considered to be related to wear resistance[10-13] and is the most commonly examined mechanical property indicator for synthetic artificial tooth materials.[11-15] In the present study the number of layers present in three types of commercially available teeth namely Livera (patented Intra Homogeneous Polymer Technology), Acryrock (cross-linked acrylic resin) and Endura (composite resin filled acrylic) were compared for the microhardness. Comparison of the microhardness between different layers in each brand was also made.

MATERIALS AND METHODS

Twenty samples of posterior teeth of 3 different brands each were evaluated. Brands used were as follows:

Group I: Livera (patented Intra Homogeneous Polymer Technology).

Group II: Acryrock (cross-linked acrylic resin).

Group III: Endura (composite resin filled acrylic).

The teeth were sectioned buccopalatally at the center of the crown with a low-speed diamond disk. Only one-half of the crown was used and other was discarded. Then the sections were embedded in auto polymerizing acrylic resin to form a base for evaluation of Vickers hardness number. The cut surfaces were polished with series of silicone carbide paper. The cross-sectioned surfaces were observed using a microscope at 10× magnification to determine the number of layers constituting the structure of each type of tooth.

It was found that both group I (Livera) and group II (Arcyrock) had a 2-layered structure whereas group III (Endura) had 3- layered structures. These layers were named as outer enamel layer and inner base layer for groups I and II. Layers in group III were named as outer enamel layer, intermediate layer and inner base layer. This is in accordance to studies conducted by Raptis CN et al (1981)[16] and Loyaga-Rendon et al (2007).[17]

The hardness of each layer of 20 sectioned artificial teeth for each brand was determined with a Vickers hardness tester (Fuel Instruments and Engineers Pvt. Ltd.) (Fig. 1) at a 300-gf load and a dwell time of 15 seconds. Three indentations were measured on each layer; namely enamel and base layers (groups I and II) and enamel layer, intermediate layer and base layer (group III) of each specimen. The diamond-shaped indentations (Fig. 2) were carefully observed in an optical microscope with a digital camera and image analysis software, allowing the accurate digital measurement of their diagonals (Fig. 3). The average length of the two diagonals

Fig. 1: Samples being tested on Vickers hardness testing machine

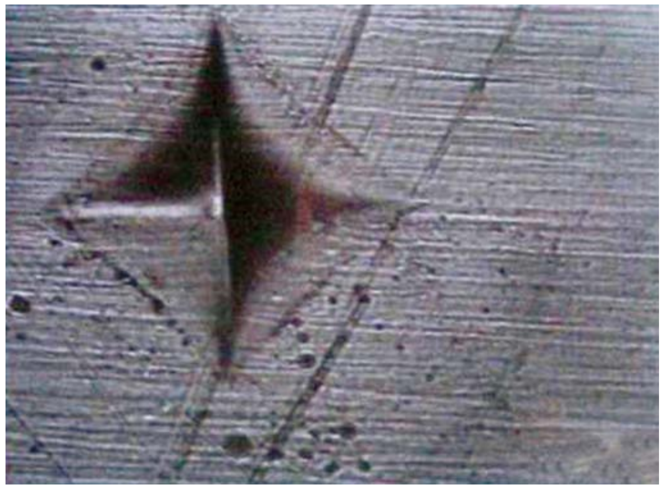


Fig. 2: Indentation made by diamond indenter

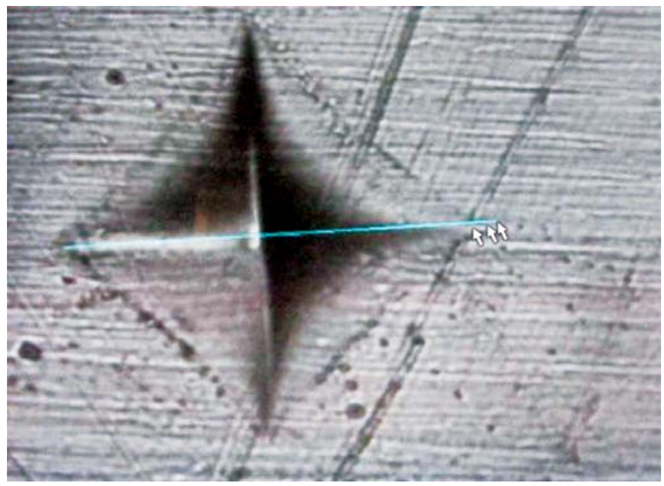


Fig. 3: Measurement of diagonal

was used to calculate the microhardness value (MHV). The representative hardness value for each sample was obtained as the average of the results for the three indentations.

RESULTS

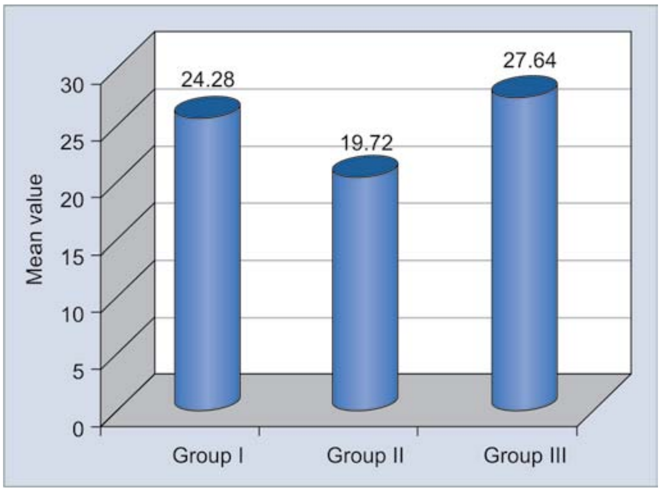
Enamel and base layers of the three groups were analyzed using one-way ANOVA/ Kruskal-Wallis test. Enamel layer of group I with mean microhardness value of 24.28 and standard deviation of 0.585 were significantly different from group II with mean microhardness value of 19.72 and standard deviation of 0.429 and group III with mean micro hardness value of 27.63 and standard deviation of 0.641 (Table 1 and Graph 1).

Base layer of group I with mean microhardness value of 19.75 and standard deviation of 0.854 were significantly different from group II with mean microhardness value of 17.82 and standard deviation of 0.394 and group III with mean microhardness value of 20.41 and standard deviation of 0.529 (Table 1 and Graph 2).

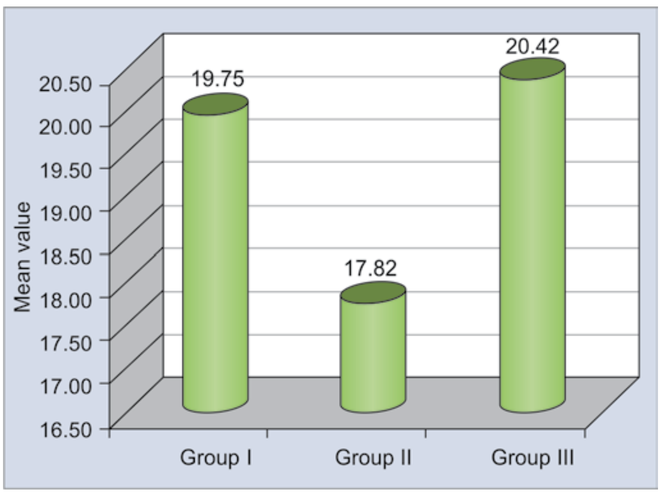
Enamel layers when compared to the base layers among the same group had significantly higher microhardness value (Graph 3).

Table 1: Mean values of different layers of groups I, II and III

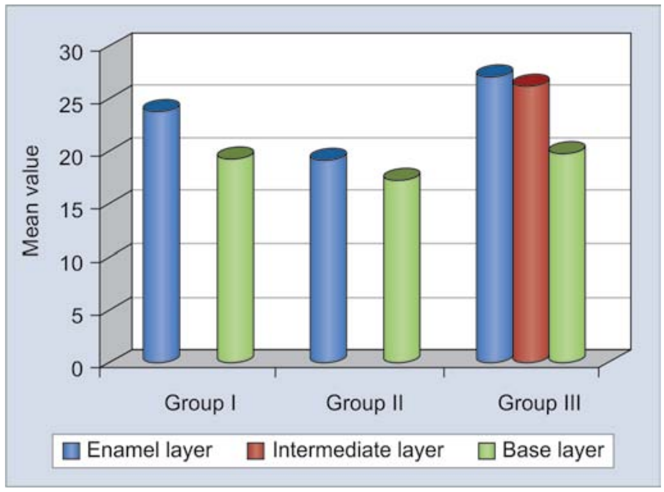
Groups	*Enamel layer*	*Intermediate layer*	*Base layer*
Group I	24.28	–	19.75
Group II	19.72	–	17.82
Group III	27.63	26.7	20.41



Graph 1: Group 1—intergroup comparison of enamel layer



Graph 2: Group 2—intergroup comparison of base layer



Graph 3: Group 3—intragroup comparison of different layers

DISCUSSION

Hardness is defined as the resistance of a material to the superficial indentation by another body in a strongly limited area. A plethora of methods is available to measure it, which are employed depending on the material class. Brinell and Rockwell hardness tests are used in conjunction with metals and alloys, whereas Vickers, Knoop and Berkovich hardness are usually measured for ceramics and Shore and universal hardness for plastics.

Vickers hardness test was used in this study because it is often easier to use than other hardness tests since the required calculations are independent of the size of the indenter, and the indenter can be used for all materials irrespective of hardness. The basic principle, as with all common measures of hardness, is to observe the questioned materials ability to resist plastic deformation from a standard source.

Three different brands Acryrock (cross-linked), Livera (patented Intra Homogeneous Polymer Technology) and Endura (composite resin filled) were evaluated in this study since they form a constituent of broad types of acrylic teeth available namely cross-linked teeth, interpenetrating polymer network (IPN) and composite resin filled acrylic teeth. Three indentations were measured on each layer of each specimen. The representative hardness value for each sample was obtained as the average of the results for the three indentations. The filler size influences the properties of the resin. They induce greater hardness, greater flexural modulus and greater flexural strength.

The microhardness of enamel layers of Acryrock (19.72 ± 0.429 kgf/mm^2) and Livera (24.28 ± 0.585 kgf/mm^2) which had significantly lower hardness than those of the enamel layer of Endura (27.63 ± 0.641 kgf/mm^2) with $p = 0.001$, might be considered to have poorer wear-resistance. Similar results were found when base layers of these teeth were compared. Base layer of Endura (20.41 ± 0.529 kgf/mm$^{2)}$ had significantly higher hardness than the base layers of Acryrock (17.82 ± 0.394 kgf/mm^2) and Livera (19.75 ± 0.854 kgf/mm^2) with $p = 0.001$. But when Acryrock and Livera were compared, Livera had significantly higher hardness for both enamel and base layers with $p = 0.001$. When enamel layer was compared to other layers (intermediate or base layers) of the same brand, it was found that enamel layer had significantly higher hardness with $p < 0.005$. The results obtained are in accordance to studies conducted earlier,[8,18-21] while other studies show no significant difference.[2,6,22]

Conflicting data may be due to the large variety of experimental designs, measuring instruments and wear-testing methods used in these investigations. The large number of denture tooth brands with different chemical compositions has created additional difficulties to the analysis of these data. In spite of the controversy, the manufacturers frequently launch on the market denture teeth made of new materials. These teeth are advertized as products with improved mechanical properties. The results of this study may assist dentists in selecting PMMA denture teeth from the standpoint of wear resistance.

Nonetheless, it is important to consider that there is not a determinant factor for predicting the wear of PMMA denture teeth. On the contrary, besides the chemical composition of the acrylic resin, several other factors should be taken into account on the abrasive process to allow the scientific understanding of the complex phenomenon of wear, namely the chewing pattern, chewing frequency, occlusion force, food abrasion, nonfunctional tooth-grinding habits, abrasive cleansers, materials' mechanical properties and dusty atmosphere.

The literature suggests that artificial teeth are very important for the success of rehabilitation prosthetic treatment, not only for esthetics but also for function. Highly wear resistant artificial resin teeth may have a significant clinical advantage for patients subject to excessive denture tooth wear as in implant prosthodontics because high wear has been observed clinically by the Hirano et al[21] during follow-up of edentulous patients treated with fixed implant prostheses has been substantial. They suspected that the high wear may be due to the rigid fixation of the prosthesis and that the replacement teeth realize the full impact of the forces during functional and parafunctional activity.

It is necessary that the dentists have an understanding of the characteristics of the artificial teeth that he recommend and the functional and anatomic characteristics of the patient, as well as his diet habits, to provide a favorable prognostic to the treatment. The rehabilitation treatment with prosthesis is combination of correct procedures, thus, objectives such as comfort, function and esthetic can be achieved and the choice of the right artificial teeth should not be based only on esthetical aspects.

SUMMARY AND CONCLUSION

Three different brands Livera (patented Intra Homogeneous Polymer Technology), Acryrock (cross-linked) and Endura (composite resin filled) were evaluated in this study which formed groups I, II and III respectively. Twenty samples of each brand were evaluated for microhardness using Vickers hardness tester.

The following conclusions were drawn:

1. Acryrock and Livera consisted primarily of a 2-layered structure; however, Endura is primarily a 3-layered structure.
2. The microhardness of enamel layers of Acryrock and Livera which had significantly lower hardness than those of the enamel layer of Endura might be considered to have poorer wear-resistance.
3. Base layer of Endura had significantly higher hardness than the base layers of Acryrock and Livera.
4. When Acryrock and Livera were compared, Livera had significantly higher hardness for both enamel and base layers.
5. When enamel layer was compared to other layers (intermediate or base layers) of the same brand, it was found that enamel layer had significantly higher hardness.

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