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Research Article



Comparative Evaluation of The Microhardness of Artificial Teeth of Various Composition

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Comparative Evaluation of The Microhardness of Artificial Teeth of Various Composition

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Abstract

Statement of the problem: To help physicians choose the right materials for treatment planning, it is necessary to investigate to the mechanical and physical characteristics of denture teeth made with new technology.

Objective: This study aims to investigate the comparative microhardness of artificial teeth with different composition.

Materials & Methods: A total of 96 specimens (n=32) were prepared using three different types of artificial teeth (conventional polymethylmethacrylate, , and nanohybrid composite) (Group CA - Conventional PMMA, Group IS - Isosite Group DCL - double cross-linked acrylic). Surface hardness values were determined using a microhardness tester (Shimadzu HMV Corporation, Tokyo, Japan) with a load of 500 g and a dwell time of 15 seconds. Three indentations were obtained for each sample and the Vickers Hardness Number (VHN) was calculated and averaged. One-way analysis of variance (ANOVA) and post-hoc Tukey HSD tests were used for statistical analysis. The statistical significance level of the data was taken as $\alpha=0.05$.

Results: The highest microhardness values were observed in Group IS (53.96 ± 8.5 VHN) and the lowest in Group CA (53.55 ± 9.9 VHN). However, no statistically significant difference was found between the groups ($P>0.05$).

Conclusions: For the durability and function of prosthetic rehabilitations performed by clinicians, the choice of artificial teeth should not be ignored, based on cost and accessibility criteria.

Keywords: Artificial Teeth, Conventional Polymethylmethacrylate, Iso-site, Double Cross-Linked Acrylic, Microhardness, PMMA

Introduction

Despite the new treatment methods developed, conventional complete dentures are still a popular treatment for complete edentulism. Removable prostheses used in complete and partial edentulism restore lost aesthetics, function and phonation to patients.¹ Artificial teeth used to replace missing teeth should ensure the continuity of chewing efficiency by showing features such as adequate bonding with the prosthesis base material, structural durability, resistance to abrasion and discoloration, low surface roughness and easy polishing.^{1,2}

Polymethylmethacrylate (PMMA) artificial teeth used in complete and partial dentures are the most preferred type of artificial teeth due to their low cost.² However, disadvantages such as low fracture resistance, color instability and surface roughness due to their susceptibility to abrasion limit their use.²⁻⁴ To overcome these insufficient properties, cross-linking agents, interpenetrating polymer network, different monomers and filling materials of different sizes have been added to strengthen the physical and mechanical properties of conventional acrylic resin teeth.⁵⁻⁶ With the help of new technological developments, new generation acrylic teeth with highly cross-linked isocyanate material, acrylic resin teeth with interpenetrating polymer network and composite resin teeth with different filling sizes have been developed.⁷

The degree of hardness is one of the most important factors to take consideration when evaluating the physical characteristics of dental materials.⁸ A material's hardness relates to its capacity to withstand localized deformation.⁹ In other words, it is the material's resistance to wear.¹⁰ The most researched mechanical characteristic for artificial dental materials is hardness, which is related to wear resistance.^{11,12} However, wear is an extremely complex mechanism that depends on many different factors.¹⁰ The wear resistance of artificial dentures is important for the long-term success of the prosthesis.⁵ Wear of occlusal surfaces can lead to a decrease in vertical face height, decreased efficiency of the masticatory muscles, and problems with aesthetics and the temporomandibular joint.¹³

In general, there are numerous studies reporting on conventional artificial teeth.¹⁰⁻¹⁵ However, studies evaluating the microhardness of next-generation artificial teeth are insufficient in the literature. Additionally, research on the mechanical and physical characteristics of denture teeth produced with new technologies is required in order to advise physicians on material selection for treatment planning. Therefore, this study aims to investigate the comparative microhardness of artificial teeth with different composition. The null hypothesis of the study is that

there is no difference between the Vickers hardness of artificial teeth made of conventional PMMA, isosite and double cross-linked acrylic.

Materials & Methods

This study evaluated the comparative microhardness of artificial teeth with different composition (conventional polymethylmethacrylate, isosite and double cross-linked acrylic). The materials used in this study are presented in Table 1.

Table 1. Content details of artificial teeth in test groups.

Material	Group Abbreviations	Trade name	Manufacturer
Conventional polymethylmethacrylate	CA	Ivostar, Gnathostar	Ivoclar Vivodent AG, Italy
Isosite	IS	SR Orthosit PE	Ivoclar Vivodent AG, Italy
Double cross-linked acrylic	DCL	SR Vivodent DCL	Ivoclar Vivodent AG, Italy

Maxillary and mandibular molars from each type of tooth group were used. Considering the size of the measurable surface area, the buccal surfaces of the artificial teeth were selected for the measurement site. The artificial teeth were divided into two parts buccally and lingually from the central fossae using a diamond saw (Microcut 201; Metkon, Bursa, Turkey). A total of 96 specimens were prepared for each artificial tooth type (n=32) and wet polished with 600 and 800 grit silicon carbide papers to ensure surface standardization.

A microhardness test device (Shimadzu HMV Corporation, Tokyo, Japan) was used to measure surface hardness values at room temperature, 500 g load, and 15-second dwell period of time. Measurements were made from the straightest surface in the middle triangular region of the buccal surfaces of the artificial tooth specimens and three indentations were obtained at random locations for each specimen. The obtained vickers hardness number (VHN) was calculated and averaged automatically with the help of a computer software program (Mares ImPA_hrd_061.vi).

Statistical analyses were performed using SPSS v.19 package program (SPSS Inc, IBM Corp, IL, USA). One-way analysis of variance (ANOVA) and post-hoc Tukey HSD tests were used. The statistical significance level of the data was taken as $\alpha=0.05$.

Results

Microhardness values of all materials are presented in Figure 1. The highest microhardness values were observed in Group IS (53.96 ± 8.5 VHN) and the lowest in Group CA (53.55 ± 9.9 VHN). The test samples were ranked in the order IS > CA > DCL. However, no statistically significant difference was found between the groups ($P>0.05$).

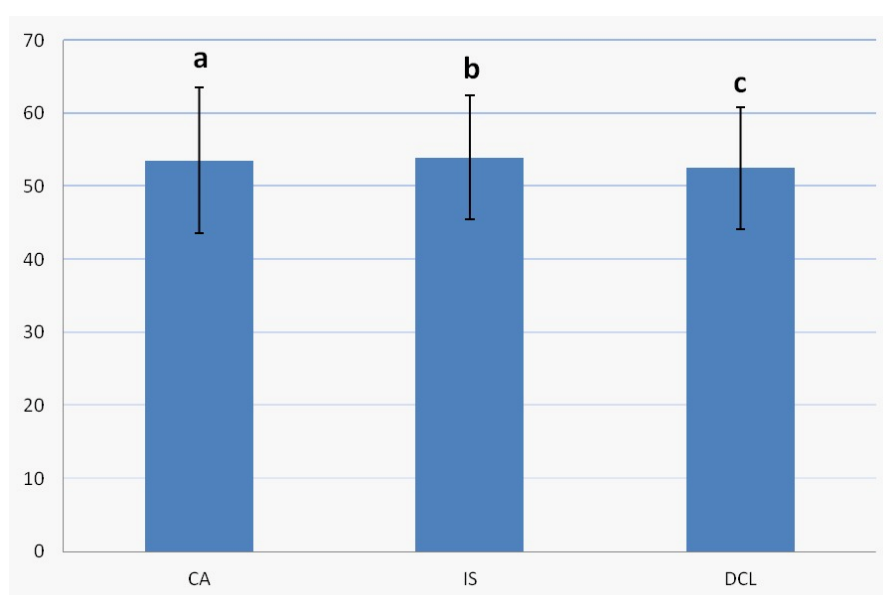


Figure. 1. Mean and standard deviation of microhardness values (same letters indicate statistical differences between groups) ($P<0.05$)

Discussion

In this study, the microhardness values of artificial teeth with different compositions, which have been in use for many years in conventional complete-partial removable and implant-retained fixed-removable prostheses, were examined. The null hypothesis of the study was accepted as there was no difference between the Vickers hardness of artificial teeth made of conventional PMMA, isocyte and double cross-linked acrylic.

The dentistry industry offers a variety of artificial tooth varieties that can be used in removable prosthesis. The most commonly used of these are those in PMMA structure.³ Acrylic resin teeth had many disadvantages such as abrasion, scratching, cracking, discoloration and

being easily affected by organic solvents when they were first produced.¹⁵ In the following years, manufacturers have solved most of these problems to a great extent by developing methods such as adding microfillers into PMMA, double-crossed linked polymer or producing teeth from composite resins etc. to increase the physical and mechanical properties of artificial teeth.^{1,11}

The microstructure of acrylic and modified resin teeth differs primarily from one another. The modified resin teeth have a cross-linked structure, whereas acrylic teeth have a linear polymer network structure. The mechanical qualities of acrylic resin are enhanced by the right quantity of cross-linking.¹² Moreover, greater polymer technologies, including "double cross-linking" and "interpenetrating polymer network," have been used to produce cross-linked acrylic resin teeth.^{12,17} These terms are defined as the cross-linking of one polymer with another three-dimensional and cross-linked polymer network. Both cross-link networks are of equal volume. They are physically intertwined and their chemical bonds must be broken to separate them.^{5,12}

The isocyte material is not PMMA based but contains a cross-linking agent based on UDMA with added inorganic microfillers. Isocyte teeth are an alternative to porcelain teeth, which erode the opposing arch, and acrylic teeth, which are very prone to wear. They are much more resistant to wear than acrylic teeth.¹⁸

Although all these improvements have improved the mechanical and physical properties of artificial teeth, they are also affected by their price. This increase in price also influences the preference of clinicians.¹⁵ The artificial teeth used in our study were conventional PMMA (Ivostar, Gnathostar), isosite (SR Orthosit PE), double cross-linked acrylic (SR Vivodent DCL). The products were preferred in our study because they are the most preferred artificial teeth due to their appropriate price-performance ratio.

One of the study's factors, hardness, is the surface characteristic of a material that has to do with how resistant it is to local deformation. The material's resistance to wear during usage is also indicated by the hardness value.⁶ Various measurement methods such as Brinell, Rockwell, Knoop, Shore, Barcol and Vickers are used in surface hardness evaluations.¹⁹ Hardness tests classified as macrohardness include Brinell and Rockwell, and microhardness tests include Vickers and Knoop.²⁰ Vickers and Knoop hardness tests can be used to determine the hardness of any material used in dentistry, including gold, porcelain, composite resins, and cements.

Brinell and Rockwell hardness tests, on the other hand, appear to be mostly utilized in metal alloys.²¹

We used the Vickers hardness measurement method in our study because of its advantages such as its ability to produce highly accurate values in surface hardness analysis of resin-based materials and the fact that the diamond tip used is not damaged over time.¹⁹⁻²¹ Unlike our study, Suzuki¹² evaluated the wear resistance of various polymeric artificial teeth and determined the hardness value using Knoop measurement method. Yaluğ and Yılmaz¹⁰ compared the hardness of commonly used artificial teeth using the Binell measurement method.

In this study, the highest microhardness values were observed in the IS group (53.96 ± 8.5 VHN), followed by the DCL group (52.49 ± 8.3 VHN) and the lowest microhardness values were observed in the CA group (53.55 ± 9.9 VHN), although there was no statistically significant difference between them. This difference may be due to their microstructural composition.

Tieh et al¹⁴ examined the optical characteristics and Vickers hardness values of conventional, milled, and 3D printed prosthetic teeth, after aging and being submerged in denture cleaners and staining beverages. The hardness values of 3D printed artificial teeth were significantly lower than those of conventional and milled artificial teeth. In our study, we evaluated conventionally manufactured artificial teeth according to their different compositions. Within the limitations of this study, artificial tooth materials of different manufacturing methods should also be evaluated.

There are also studies^{8,12,16} in the literature that include hardness values of artificial teeth of different compositions measured by soaking in different solutions, which is one of the limitations of this study. The impact of several denture cleansers on the microhardness and surface roughness of various types of artificial dentures has been evaluated by Yüzügüllü et al⁸ They found that, with the exception of the most recent generation of nanohybrid composite teeth, using Corega tablets had an impact on the microhardness and surface roughness of all artificial prosthetic teeth. Neppelenbroek et al¹⁶ investigated how various denture cleaners affected the Vickers hardness and surface roughness of two different varieties of cross-linked artificial teeth. They concluded that the daily cleaning procedure in denture cleansers, which is typically recommended for removable dentures, can have a negative impact on the surface hardness values of cross-linked artificial teeth.

It has been stated that long-term clinical studies are the most reliable method for the evaluation of various structural properties of dental materials. However, in vitro studies are mostly

preferred because standardization cannot be achieved due to technical difficulties, inability to repeat the study methodology during clinical applications, length of the study process, variability of factors related to the patients to be included in the study (such as dentition, masticatory forces, nutritional differences). This is one of the limitations of our study.

Since hardness is a measure of wear in the comparison of materials in the same class, the hardness of the materials was first determined in this study. Future research is aimed to determine the physical properties and abrasion resistance. In addition, future studies should focus on digital PMMA materials with different compositions that can be produced by different methods at the current state of dental technology.

Conclusions

The role of clinicians in the selection of artificial teeth for prosthetic rehabilitation is to inform the patient about the options, to choose the teeth that will provide the ideal rehabilitation of the occlusion in accordance with the patient's aesthetic expectations. In this process, physical and biological factors related to the patient, cost and accessibility criteria should also be taken into consideration.

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