ORIGINAL ARTICLE

EFFECT OF LACTIC AND ACETIC ACIDS ON THE MICROHARDNESS OF TWO CERAMIC BASED NANOHYBRID COMPOSITES

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ABSTRACT

The organic matrix of the resin-based composite (RBC) restoration in the subject is susceptible to degradation by acids. Newer RBC have incorporated organically modified ceramics into their formulations. The objective of the study was to document the effect of lactic and acetic acids on the microhardness values of two ceramic based nanohybrid composites (CBNC) after different immersion periods. This experimental laboratory-based study was conducted on 60 specimens, 30 in each of the two CBNCs (Tetric N-Ceram and Ceram-X). The test specimens were made in a standard split mold having dimensions of10 mm diameter and 2 mm thickness. The specimen was cured and the baseline Vickers hardness number (VHN) was measured and the remaining microhardness assessment was done after the various immersion periods of 2 days, 7 days and 21 days. The data were analyzed in statistical program (SPSS version 25.0). Descriptive statistics along with repeated measures ANOVA was used for the comparison of microhardness. The level of p-value to be significant was set as 0.05. The change in microhardness of both Tetric N-ceram (p=0.671) and Ceram-X (p=0.530) after baseline, 2 days, 7 days and 21 days after immersion in various media were statistically insignificant. It can be concluded that there was no effect of acids on surface microhardness of both test materials.

Key Words: *Hardness test, dental composite, dental material, composite resin*

INTRODUCTION

Since the introduction of visible light cured resin-based composites (RBC) as direct restorative materials, their use has increased exponentially.[1] These materials have the unique properties; of adhering to acid etched enamel and dentine, superior aesthetics, ease of handling and direct placement.[2,3] Their high bond strength and load bearing properties has changed the approach of dentists towards management of dental caries i.e. from extension for prevention to prevention of extension.[4] Early RBC were composed of quartz filler particles (1-50µ) in size which had poor aesthetic properties and polish ability.[5]

Ceramic based nanohybrid composites (CBNC) consist of blend of large glass filler particles (0.4-5µ) with added nanometer sized ceramic filler particles. They bear stress better than conventional RBCs because of increased surface area and also have better colour stability, surface smoothness, translucency and aesthetics.[6] In addition, the amount of uncured resin with increasing curing thickness is less in nanohybrid RBCs compared to conventional RBCs.[7] Due to their superior properties, CBNCs have replaced conventional RBCs in contemporary clinical dentistry.[8]

The longevity of RBC depends on numerous factors like dentist's technique, type of RBC used, type of cavity restored, presence of para-functional habits and tooth preparation design.[9] Furthermore, oral environment is complex with varying pH and temperature levels. Research has highlighted the role of dental biofilms in production of acids irrespective of the oral hygiene of subjects. Bacteria in the dental biofilm utilize carbohydrates to form acids mainly lactic and acetic acid.[10] The organic matrix of the RBCs in the oral environment is susceptible to degradation by these acids. These acids have been shown to have damaging effects on the polymer network of RBC resin adversely affecting their physical properties including; microhardness.[11]

Studies have investigated the effect of different media and organic acids present in dental biofilm on the microhardness of different types of RBC resins. Study by Da Silva et al reported that lactic acids found in dental biofilms can significantly reduce the microhardness of nanofilled, midifilled and silorane RBCs.[12] However, they did not report the effect of acetic acid on these RBCs.

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Microhardness value is an important characteristic of restorative materials associated with compressive strength and resistance to softening.[13] Microhardness value is an important characteristic of restorative materials associated with compressive strength and resistance to softening.[14]

Previous studies are on silorane RBC, while this work is to determine effect of acid on CBNC. CBNC's are newly available as compared to silorane RBCs, so we wanted to see the behavior in the changes in the VHN values in the clinically simulated acid environment. Keeping in view of the above-mentioned facts, the purpose of this study was to determine the effect of the various periods of immersion 0.01M conc. of lactic and acetic acid produced by bacteria present in oral biofilms on the microhardness of CBNCs.

MATERIALS AND METHODS

A total of 60 specimens were made, 30 in each of the two CBNCs (Tetric N-Ceram, Ivoclar-Vivadent, Schaan, Liechtenstein) and (Ceram-X, Dentsply De-Trey, Konstanz, Germany). This was an experimental laboratory-based study and the study was conducted at department of science of dental materials, Peshawar Dental College and Hospital, Peshawar and Materials Research Laboratory (MRL) and Centralized Resource Laboratory (CRL), University of Peshawar.

The test specimens in each of the two CBNCs were made in a standard mold according to ASTM standard (ASTM E384-17). The mold had the dimensions of10 mm diameter and 2 mm thickness. According to the manufacturer's recommendation the specimens were cured from both sides for 30 seconds by using LED light (Valo, Ultradent, Products Inc., South Jordan, USA) with 1,000 mW/cm^2 intensity and then the specimen was recovered from the mold. The specimens that were having uniform thickness and margins were included and specimens having cracks or voids were excluded.

Thirty specimens from both the CBNC were equally divided into different immersion groups by non-probability convenience sampling technique. The immersion groups were Distilled water (Control medium) pH= 7.0, Lactic acid pH= 4.0 (0.01 M) and Acetic acid pH= 4.0 (0.01 M). The microhardness values were assessed at baseline (0 day), 2 days, 7days and 21days respectively.

The surface of each specimen was divided into 4 quadrants. On one quadrant, the baseline (0 day) Vickers hardness number (VHN) was measured and the remaining 3 quadrants were used for microhardness assessment after the various immersion periods of 2 days, 7 days and 21 days.

The microhardness was tested with digital microhardness tester (HVS-1000, China) under a load of 100g for 30 seconds. Each specimen was tested for microhardness three times with more than 1 mm distance from the specimen margin at different points and their average calculated.

Descriptive statistics were computed for the data. Mean and standard deviation values of the VHN for each of the three groups and materials on completion of each of the mentioned immersion periods were calculated. Repeated measures ANOVA was used for the comparison of the significance of the differences of the mean values for the microhardness of the test CBNCs before and after immersion in the respective media and P values generated using t-test. The level of significance was set at 5% ($p \geq 0.05$).

RESULTS

The microhardness value of Tetric N-ceram after immersion in distilled water at baseline (50.7±5.2) showed slight reduction after 2 days (47.2±4.4) and again increased to the baseline level at 7 days (50.6±3.2) and 21days (50.0±2.4) (Figure 1). The microhardness of Tetric N-ceram after immersion in lactic acid was similar to baseline (46.3±4.9) and after 2 days. (45.8±3.0) but after that it increased (Figure 1). While after immersion in lactic acid the microhardness of Tetric N-ceram did not change after 21 days (Figure 1). The microhardness of Tetric N-ceram after immersion in acetic acid showed gradual increase from baseline (42.3±4.1) till 21 days (45.2±4.7) (Figure 1). Microhardness of Ceram-X after immersion in distilled water showed increase from baseline (53.6±5.3) up to 21 days (57.1±5.7) (Figure 2). Microhardness of Ceram-X after immersion in Lactic acid solution showed no change in microhardness from baseline (48.4±3.4) till 7 days (48.2±2.8) (Figure 2). Microhardness of Ceram-X after immersion in acetic acid solution did not show much variation and all values were close to the baseline values (49.6±3.5) (Figure 2). All these changes of microhardness of both Tetric N-ceram and Ceram-X after baseline, 2 days, 7 days and 21 days after immersion in various media were statistically insignificant (Table 1).

DISCUSSION

Early Resin based composites (RBC) were composed of quartz filler particles which had poor aesthetics and polish ability.[5] Ceramic based nanohybrid composites (CBNC) consist of blend of glass filler particles with added nanometer sized ceramic filler particles.[6] The newer generation of CBNC are Tetric N ceram (Ivoclar-Vivadent, Schaan, Liechtenstein) and Ceram-X (Dentsply DeTrey, Konstanz, Germany).

Tetric N ceram (Ivoclar-Vivadent, Schaan, Liechtenstein) is a nano-hybrid composite containing ceramic/glass filler and nano additives that improve the viscosity and wettability of the filler particles with the resin.

TABLE 1: COMPARISON OF MICROHARDNESS OF CBNC IN VARIOUS MEDIA AFTER DIFFERENT IMMERSION PERIODS.

Type of RBC		Sum of Squares	Df	Mean Square	F	Sig.
Tetric N-ceram	Between Groups	12.826	3	4.275	0.521	0.671
	Within Groups	295.430	36	8.206		
	Total	308.257	39			
Ceram-X	Between Groups	684.647	3	5.21	0.472	0.530
	Within Groups	886.051	36	7.303		
	Total	1570.698	39			

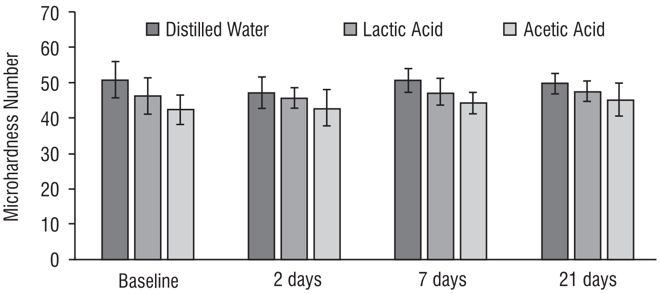

Fig 1: Microhardness of Tetric N Ceram in relation to different test media and immersion times

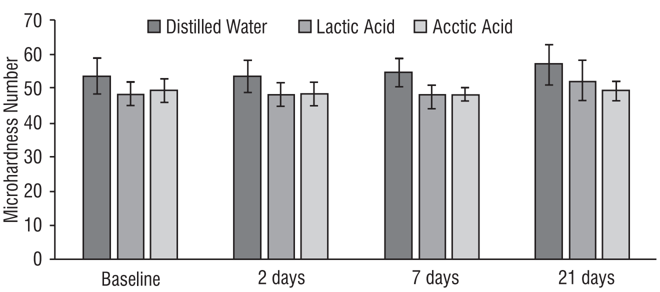

Fig 2: Microhardness of Ceram-X in relation to different test media and immersion times

Furthermore, the company claims that the resin used in this product is more hydrolytically stable under acid and alkaline environments.[5]

Ceram-X (Dentsply DeTrey, Konstanz, Germany) is a nano-hybrid composite which contains a novel filler system known as SphereTEC. The manufacturer claims that use of SphereTEC™ filler system reduces the amount of resin needed in a composite which in turn provides better mechanical properties.[15]

The aim of the current study was to document the effect of 0.01 M concentration of lactic and acetic acids on the microhardness values of two CBNC after immersion period of 2 days, 7 days and 21 days. Most of the previous studies were on silorane based RBC.[17] The longevity of the RBC restoration in the harsh oral environment is one of the great challenge.[17] According to Distler and Kröncke [18], lactic acid and acetic acid account for 70% of the acids present in bacterial plaque. So, we investigated the effect of these two acids on CBNC in the present study. Microhardness of nano-hybrid is an important property related to the degree of polymerization of material and distribution of filler, which affects the resistance of RBC to wear as well as the wear of the opposing teeth or restorations.[19]

In the current study the microhardness of CBNC did not change as the time of immersion in distilled water increases. Kalachandra et al.[20] reported that water absorption can adversely affect the mechanical property of RBC restorative materials. However, the methodology of Kalachandra et al.[20] was different from current study i.e. they used conventional RBC in their study and measured mechanical property of the RBC by determining of elastic modulus (not microhardness as in this study).

In this study the concentration of 0.01M was used for both acids in order to replicate the oral PH of in vivo acids. HashemiKamangar et al.[21] also used such concentration in their study on the effect of acids on microhardness of a silorane-based RBC. The microhardness of Ceram specimens did not decrease after immersion in both test acid solutions. Tetric N-ceram also did not show any decrease in microhardness after immersion in the test acid solutions. It has been reported in literature that after immersion of RBCs in acid it can cause degradation of the organic matrix in turn lead to reduction in microhardness value.[21] The results of this study showed that the microhardness of Ceram-X and Tetric N-Ceram showed no change after immersion in all the mediums. Previous studies conducted on effect of various acid on microhardness of nano-hybrid RBC reported different results than our study.[21]

The difference in this study as compared to previous one may due to improvement in the composition of CBNC i.e incorporation of better filler particles and better filler surface treatments as manufacturer claims to use novel methods of filler and resin interaction and bonding.

Limitation of the present study was that the instrument used for microhardness testing was not fully automated and addition of different type of RBC materials for better comparison.

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CONCLUSION

Within the limitations of this study it was concluded that the microhardness of Ceram-X and Tetric N-Ceram did not change significantly after different immersion periods in different immersion media.

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CONTRIBUTIONS BY AUTHORS

Both the authors contributed substantialy.