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CAN OMNICHROMA REVOKE OTHER RESTORATIVE COMPOSITES? MECHANICAL AND PHYSICAL ASSESSMENT OF OMNICHROMA DENTAL RESIN RESTORATIVE COMPOSITE: AN IN- VITRO STUDY

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ABSTRACT

Objective: The study aimed to investigate the compressive strength, flexural strength and surface micro-hardness of Omnichroma composite. Assessment of water sorption and solubility, also color matching of Omnichroma restorations with the tooth structure was performed. Accelerated aging by thermocycling was done to investigate the effect of thermocycling on the tested properties.

Materials and methods: Compressive strength was tested on sixty cylindrical specimens. Flexural strength was measured for sixty rod-shaped specimens. Surface micro-hardness was tested for sixty disc specimens. To evaluate water sorption and solubility; sixty disc specimens were tested. To assess the color parameters (CIE Lab); class V cavities were prepared in 20 human molars and restored with Omnichroma composite. Color measurements were performed using a spectrophotometer. Tests were performed at 24 hours of storage (group I), and after thermocycling for 5000 cycles (group II), and after thermocycling for 10,000 cycles (group III).

Results: There was a significant difference between groups concerning the compressive strength, flexural strength, and surface micro- hardness. The highest values were found in group I. Concerning water sorption; there was no difference detected between groups. However, for solubility testing the highest value was found in group III. Regarding the change in color the highest ΔE value was measured at group III.

Conclusions: Thermocycling aging of Omnichroma composite can cause deterioration in its compressive strength, flexural strength and micro-hardness, in addition to increasing its solubility. Shade matching of Omnichroma can be adversely affected by thermocycling.

KEY WORDS: Omnichroma, mechanical properties, water sorption, color parameters, thermocycling.

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INTRODUCTION

Advancement in esthetic dentistry always occurs at a rapid rate to achieve the demand of more natural appearance of composite restorations.

Omnichroma was introduced in 2019 by Tokuyama Dental America as the first dental resin composite material that could match the shade of any tooth. Possessing this unique property can provide quick and easy steps for obtaining a satisfactory esthetic restoration. In addition, Omnichroma was known to save the clinician time by eliminating the need for shade selection.[1]

Smart Chromatic Technology of Omnichroma was offered by Tokuyama Dental America; where the material can attain a wide range of color matching, by generating red-to-yellow structural color comparable to natural teeth. As this red-to-yellow structural color is produced, it combines with the reflected light, as well as with the color of the surrounding tooth structure in an additive color mixing process. This process maximizes the composite's ability to match the natural tooth shade. Utilizing this generated structural color, combined with the additive color mixing system lead to the needless use of pigments. The fillers used in Omnichroma were of uniform size (260nm) spherical silica fillers; formed by a special technique known as the Sol-Gel method.[1, 2]

The Sol-Gel method is based on the production of fillers from filler cores in an organic solvent, and consequently allows a steady and slow growth of fillers from the cores by controlling the reaction duration. The Sol- Gel method differs from the conventional filler manufacturing methods (crushing the glass materials till obtaining the desirable size) in that it offers the possibility of obtaining uniformly shaped spherical fillers that promotes better behavior of light transmission through the material structure. Conversely, the conventional crushing techniques give rise to fillers of variable sizes and shapes, which can alter the structural color and impede light transmission through the material.[2] Another major benefit of the Sol-Gel method is the possibility of controlling the refractive index of the filler by controlling the reaction conditions. If the refractive indices of the matrix material and fillers are equivalent; the composite resin will be of high translucency. On the other hand, if there is a significant difference in the refractive indices of the fillers and the matrix, the composite will be shifted towards more opacity. The refractive index of resins changes after polymerization, considering that the refractive index of the cured resin tends to be higher than that before curing. To convey a satisfactory color matching for Omnichroma composite, it was designed to change from being opaque white before curing to a more translucent material after curing.[1]

In dental resin composites, filler size can significantly affect the mechanical and esthetic characteristics of the composite. It is known that smaller filler sizes produce a superior surface glossiness, though it makes it difficult to increase the filler content.[3] These smaller sized fillers can lead to increased polymerization shrinkage and poor mechanical characteristics; such as reduced flexural strength. Studies conducted by Tokuyama mentioned that filler content begins to fall significantly when the size is below 100nm but is nearly constant at sizes above that. In addition, it showed maximum compressive strength for particle sizes ranging from 100 to 500nm. It was also mentioned that surface hardness reaches the highest value at particle sizes ranging from 100 to 500nm.[1,2] Tokuyama utilized these information to develop a balance between both the esthetic and mechanical characteristics; by using the 260nm sized particles.

Using Omnichroma includes direct anterior and posterior restorations, direct composite veneering material and also for closure of diastema, in addition to porcelain and composite repair.[3, 4]

To criticize a newly introduce composite resin restorative material; many mechanical properties should be covered. Among these properties is the compressive strength of the material that reflects the ability of the restoration to withstand masticatory stresses. Another laboratory test used to evaluate mechanical properties is flexural strength testing. This test simulates the forces that are extended in stress stricken areas that create tensile and compressive forces simultaneously around the point of loading.[5] Furthermore, one of the most important features is the surface hardness of the restorative material, as it is highly relevant to its wear resistance and accordingly its esthetic characteristics. Since strength and durability of restorative materials are highly affected by the intraoral conditions, therefore it is of prime importance to test the value of water sorption and solubility of the resin composite material, as well as the effect of thermal changes on its mechanical and esthetic aspects.

Research gap

Despite the manufacturer's announcement of esthetic success of Omnichroma, the literature included little and insufficient information regarding its mechanical properties and clinical efficacy, as well as the effect of in- vitro accelerated aging on mechanical and esthetic properties. Long term evaluation of different mechanical properties of Omnichroma composite was not satisfactorily covered in the literature, despite that these properties have a remarkable effect on the durability and clinical performance of the composite restorations. Comparing the obtained data to the manufacturer claimed values must be precisely fulfilled; in order to attain an affirmative and convincing analysis of Omnichroma composite properties. Water sorption and solubility of Omnichroma composite are other critical scientific aspects that should be assessed and correlated to the mechanical and esthetic properties of the composite, pertaining to their relevance to thermocycling aging. The literature included little data concerning the effect of thermocycling on shade matching of Omnichroma composite restorations with the surrounding tooth structure. This item should be covered in order to properly criticize the durability of shade matching.

Aim of the study

To find an evidence based answer for the proposed question about Omnichroma ability to revoke other restorative composites, the current study was targeted towards assessment of compressive strength, flexural strength and surface micro-hardness of Omnichroma composite. Assessment of water sorption and solubility of the composite was also included in the study. The assessed properties were measured at 24 hours of specimens' preparation, after thermocycling aging at 5000 cycles; which is approximately equivalent to 6 months intraoral service, and after thermocycling at 10,000 cycles; which is approximately equivalent to 1 year intraoral service. The study with this design can take part in evaluation of Omnichroma restorative composite on a long term service. Color matching between the tooth structure and Omnichroma composite restoration was an important objective assessed throughout the study, to investigate the effect of thermocycling aging on the restoration/ tooth color matching.

Specimens grouping

For each of the assessed properties; specimens tested at 24 hours of preparation were considered group I. However, those tested after thermocycling for 5000 cycles were considered group II. Those tested after thermocycling for 10,000 cycles were considered group III.

Null hypotheses

Null hypothesis 1 claimed that thermocycling aging has no effect on the tested mechanical properties of Omnichroma composite. Null hypothesis 2 claimed that Omnichroma composite will not show any change in value of water sorption or solubility by thermocycling. Null hypothesis 3 claimed that color matching between Omnichroma restorations and the surrounding tooth structure would be preserved with no significant difference after thermocycling.

MATERIALS AND METHODS

The composite resin assessed in the study was Omnichroma light-cured radiopaque single shade universal composite; by Tokuyama Dental Co., Tokyo, Japan. The filler system is uniform sized supra-nano spherical filler (260nm spherical SiO2-ZrO2) 79% by weight (68% by volume). The resin system is urethane dimethacrylate, tri-ethylene glycol dimethacrylate , mequinol, dibutyl hydroxyl toluene and ultra- violet rays absorbers.

Sample size calculation and research design

A total number of 260 specimens of Omnichroma restorative composite resin (Tokuyama Dental America) were used to perform the current study. Sample size calculation was done using G Power version 3.1.9 at 90% power and 95% confidence interval. Twelve specimens were recommended for each test. However, the number of specimens used in the study was increased to 20 specimens to attain more reliable results; so that for each mechanical test, a total of 60 specimens were tested. Twenty specimens were measured at 24 hours after preparation **(Group I)**; they were stored in distilled water in an incubator (Titanox, ART.A3-213-400I, Italy) at 37°C till being tested. Another 20 specimens were tested after 5000 thermocycles **(Group II)**. In addition, 20 specimens were tested after 10,000 thermocycles **(Group III)**. This gave rise to 180 specimens were tested for the mechanical assessment (compressive strength, flexural strength and surface hardness). Regarding evaluation of water sorption and solubility; 20 specimens were measured at the three previously mentioned aging procedures, with a total of 60 specimens. Concerning the Omnichroma restoration/ tooth color matching; 20 specimens were prepared as class V cavities in human molars and restored with Omnichroma to be tested for color matching as dependant samples. Thus, the total number of specimens in the present study was 260 specimens. The design of the present study would offer an assessment of the tested properties under the effect of thermocycling aging.

Composite specimens' preparation

For all tests, composite specimens were prepared using the recommended molds suitable for the performed test. The restorative Omnichroma composite was packed in the used mold on top of a glass slab covered with a celluloid strip (Maquira, Brazil). The composite resin was compacted into the molds using Teflon coated plastic restorative instruments. Another celluloid strip and a glass microscopic slide were put on top of the packed composite before curing, gently adapted and pressed by fingers, and then loaded on top by a 300 gm weight for 30 seconds, to standardize the load on all specimens. The load was removed after 30 seconds and excess material was carefully removed using an explorer. A glass slide was put on top of the specimen and light curing was performed using LED curing unit (DentAmerica LITEX 696, California, USA) for 20 seconds. The diameter of the light-curing tip was 8.5 mm, and the light output was 1200 mW/cm2.

The light tip of the curing unit was placed in contact with the glass slide to standardize the curing distance. Curing in compressive strength was done from both sides of the specimen because the thickness was 4 mm, however for other tests; curing was done once from one side.

The intensity of the curing unit was regularly checked every five specimens using a radiometer (DentAmerica, Model 662, California, USA).

After curing, composite specimens were manually smoothed with 1200 Grit carbide silicon sheets. Then, the polishing and finishing was done by Sof-Lex discs (3M ESPE, St. Paul, MN, USA).

All over the study, thickness measurements for molds and specimens were done using a digital caliber Mitutoyo 293–561 (Mitutoyo, Tokyo, Japan).

Specimens were prepared according to ISO standards for resin based restorative materials 4049-2019.[(6)]

I- Compressive strength evaluation

I.A. Specimens' preparation

Sixty cylindrical shaped specimens of Omnichroma composite were prepared using a split Teflon mold with a hole of dimensions 6 mm height and 4 mm diameter. Specimens were light cured for 20 seconds from both sides.

I.B. Compressive strength testing

Specimens were loaded under compression using a universal testing machine (Instron Instruments 3365, USA, load cell= 5kN), at the cross-head speed of 1 mm/min till failure. The load at failure (in Newton) was determined and divided by the cross sectional area of the specimen (in mm^2) to determine the compressive strength in MPa.

II- Flexural strength evaluation

II.A. Specimens' preparation

Sixty rod-shaped specimens of Omnichroma material were prepared, having the dimensions of 2 mm × 2 mm × 25 mm using a split Teflon mold.

For each specimen; three irradiations were performed in order to irradiate the whole specimen. A shot was done in the middle of the specimen, then two shots (one to the right and one to the left), where the light curing tip was positioned aided by the ends of the specimen.

II.B. Flexural strength testing

Three-point bending flexural test (transverse strength) was performed using the universal testing machine, at the cross-head speed of 1 mm/min till failure. The load at failure was determined and used in the flexural strength (transverse strength) equation:

$$TS = F\,L / W\,(Th)^2$$

TS: Transverse strength (flexural strength) in MPa.

F: Load at failure in Newton

L: Length of the specimen in mm

W: Width of the specimen in mm

Th: Thickness of the specimen in mm

III- Surface micro-hardness evaluation

III.A. Specimens' preparation

For micro-hardness testing, 60 disc shaped specimens were prepared in a split Teflon mold of a circular opening 8 mm in diameter and 2 mm in thickness.

III.B. Surface micro-hardness testing

Vickers test was used to perform the microhardness test. Vickers hardness test was performed using a micro-hardness tester (Nexus 4000 TM, Innovatest, Netherland, Europe). The indenter was applied on 3 different areas of the surface of each sample; under 300 g loading for 15 s. The examination of the indentation was performed at 20X magnification, and the average of the three readings was recorded for each specimen.

Thermocycling aging

The temperature range in thermocycling was 55°C and 5°C. The immersion time in the hot and cold water tank was 30 s and the transfer time from one tank to another was 5 s. For each mechanically assessed property; 20 specimens were thermocycled for 5000 cycles and another 20 specimens were thermocycled for 10,000 cycles.

IV- Water sorption and solubility testings

For the water sorption and solubility measurements, a total of sixty disc specimens were prepared. A split Teflon mold for the preparation of a disc specimen was 8 mm in diameter and 2 mm thickness.(6-8) Testing procedures were performed in compliance with the ISO 4049:2019(6) standards. Twenty discs were tested for each group. The discs were dried by placing them in a desiccators (Fisher Scientific, Loughborough, Leicestershire, United Kingdom) containing dry silica gel, at 37 ^{O}C until a constant weight had been achieved (the recorded weight loss was less than 1×10^{-3} g). This weight was denoted as (m1) which was considered the initial mass of the specimen. The discs were then placed in a glass vial containing 100 ml of distilled water. The vials were wrapped in aluminum foil to exclude light and placed in an incubator at 37^{O}C and at intervals (1, 6, 24 h, and subsequently at 2 days intervals) removed, blot dried with an absorbent sheet and weighed, then returned to water; this was continued till obtaining a constant weight; that had been denoted as (m2). After that, the discs were removed from water and replaced in the desiccator at 37^{O}C until a constant weight had been achieved. Each specimen was subsequently dried by being placing in a vacuum oven at 60^{O}C for 24 h and then reweighed for the last time. The recorded weight was denoted as (m3).

For weight measurements: an analytic balance that can measure accurately to within 0.0001 gr (4 digits sensitive balance, Sartorious AZ 214, Sartorious Mechatronics Corp, USA) was used. The balance was mounted on a non- vibrating table. A constant weight was considered when the measured mass change for a specimen was less than 0.1 mg.(9)

To calculate the volume (V) of each specimen, $V= \pi r^2 h$ in mm^3, where r is the radius of the specimen and h is its height (thickness).

Water sorption and solubility (in µg/mm^3) of each specimen was calculated according to ISO 4049(6), using the following equations:

- **Water sorption = (m2- m1)/V**
- **Solubility = (m1 – m3)/V**

Where:

m1: Initial mass before immersion in distilled water (µg)

m2: Mass after immersion in distilled water (µg)

m3: Final mass after drying (µg)

V: Volume in mm^3.

Measurements of water sorption and solubility were performed at 24 hours for group I. Measurements obtained after 5000 thermocycles were for group II, and those obtained after 10,000 thermocycles were for group III.

Thermocycling was performed as previously mentioned for that concerning the mechanically assessed properties.

V- Color matching test between the tooth structure and Omnichroma restorative composite.

V.A. Teeth collection

Freshly extracted 20 human molars were collected for the study. Teeth were extracted due to orthodontic reasons or periodontal problems. Teeth were collected from Oral Surgery Department, Faculty of Dentistry, Ain- Shams University. All teeth were cleaned from any calculus deposits or soft tissue debris using an ultrasonic scalar (Cavitron Plus TM, Dentsply Sirona, Canada, 30000 vibrations/sec), then polished with a polishing paste (Dental I-Fast, Lithuania) using a polishing brush. They were microscopically examined at 20x magnification to assure the absence of cracks or defects. Teeth with cracks or caries were excluded. Enumerating each tooth from number 1 to number 20 was done using nail polish, in order to obtain dependent samples throughout the shade assessment testing.

V.B. Cavity preparation and restoration

Trapezoidal Class V cavities were prepared in the buccal surface of teeth. The cavity dimensions were

4 mm (occlusal border), 2mm (cervical and proximal borders), and 1.5mm depth. The cavity was prepared 0.5 mm coronal to cement-enamel junction using a fissure carbide bur (Meisinger, Germany, size 010), in a high speed hand piece with air water spray. A 45-degree bevel was placed on the occlusal wall of the cavity. The used burs were replaced by new ones every 5 cavities. The cavity dimensions were controlled and checked using a periodontal probe. All the prepared cavities were rinsed thoroughly with water, and air-dried. Total- etching technique was applied; where the whole cavity of the tooth was acid etched with 37% phosphoric acid gel (Meta Etchant gel, Meta Biomed) for 15 seconds, then rinsed thoroughly with water spray. Excess water was removed by blotting the surface with a moist cotton pellet for 2- 3 seconds, leaving the preparation visibly moist. The bonding agent (Bisco All- Bond Universal, USA) was then applied in two separate coats to the etched cavity with a micro-brush. Scrubbing the preparation for 10- 15 seconds per coat was performed, and then air-thinning was done with an air stream till the adhesive be of no visible movement. Light-curing of the adhesive was then performed for 10 seconds using the LED curing unit. Restorative material was packed in the prepared cavities using Teflon coated plastic filling instruments, and the restoration was covered with a celluloid strip to obtain a smooth surface and avoid oxygen inhibited layer. Light-curing was then done for 20 seconds and specimens were then stored for 24 hours in distilled water at 37°C in an incubator, then before color measuring specimens were gently air dried.[10]

V.C. Measurements of color parameters

Color measurements were expressed according to the Commission International de l' Eclairage (CIE) Lab coordinates. CIE Lab is expressed by the "L" coordinate representing color luminosity having values ranging from 0 (for black) to 100 (for white). The chromaticity coordinates are represented by "a" that denotes the green- red coordinate (–a is green, + a is red). Also, the "b" coordinate represents the blue- yellow (-b is blue, +b is yellow).

Color measurements of Omnichroma dental resin composite restorations were recorded using a spectrophotometer (Vita Easy Shade Advance 4, Zahnfabrik, Bad Sackingen, Germany) which calculates CIE Lab values for 2° observation and D65 illumination curve. It uses a hand hold probe with 5 mm measurement area and emits light using one halogen lamp. The single tooth measurement mode was selected for measuring the composite restoration. Calibration was performed by placing the covered probe tip on the calibration port built in the equipment (one standard for calibration) before each specimen measurement; and each specimen was measured by holding the probe tip at 90° to the middle of the tested area.

To take the readings of the tooth structure for each restored molar, three reading were recorded at three areas surrounding the restoration (left, right and above) by applying the average mode of measuring. The probe tip was placed perpendicular to the assessed area to obtain precise readings. The means of the readings were calculated and recorded as the color measurements of the tooth structure.

For each specimen after 24 hours storage; ΔL, Δa, Δb values (between the restoration and the surrounding tooth structure) were calculated using the verification mode of the Vita Easy Shade that can express color difference as ΔE and in L a b values. Giving three stars means very good matching, two stars means good matching, while one star means incorrect shade matching. The color change (ΔE) is the calculation measurement that expresses the human visual judgment of differences between two perceived colors. Regarding the CIE Lab, ΔE is calculated according to the following equation:

$$\Delta E = [(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2]^{1/2}$$

Color parameters of each restoration and the surrounding tooth structure for each specimen were then re-obtained after 5000 thermoycling, and then after 10,000 thermocycling, in a dependent sample measuring procedure.

Statistical analysis

Numerical data were presented as mean and standard deviation (SD) values. Shapiro-Wilk's test was used to test for normality. Homogeneity of variances was tested using Levene's test. Data were parametric and showed variance homogeneity and were analyzed using one-way ANOVA followed by Tukey's post hoc test for independent samples and repeated measures ANOVA followed by Bonferroni post hoc test for dependent samples (color changes test). The significance level was set at $p<0.05$ within all tests. Statistical analysis was performed with R statistical analysis software version 4.1.3 for Windows (R Core Team 2022. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria.)

Intergroup comparisons are presented in table (1) and in figures from (1) to (6)

RESULTS

I- Results of compressive strength testing (MPa).

There was a significant difference between different groups ($f=1123.67$, $p<0.001$). The highest value was found in group (I) (414.92±7.67 MPa), followed by group (II) (396.75±8.28 MPa), while the lowest value was found in group (III) (289.84±10.79 MPa). Post hoc pairwise comparisons were all statistically significant ($p<0.001$).

II- Results of flexural strength testing (MPa).

There was a significant difference between different groups ($f=2938.84$, $p<0.001$). The highest value was found in group (I) (121.05±1.74 MPa), followed by group (II) (100.03±1.85 MPa), while the lowest value was found in group (III) (80.72±1.36 MPa). Post hoc pairwise comparisons were all statistically significant ($p<0.001$).

III- Results of surface micro-hardness testing (VHN :kgf/mm2).

There was a significant difference between different groups ($f=901.64$, $p<0.001$). The highest value was found in group (I) (91.55±1.62 VHN), followed by group (II) (75.60±1.48 VHN), while the lowest value was found in group (III) (74.51±1.12 VHN). Post hoc pairwise comparisons were all statistically significant ($p<0.001$).

IV- Results of water sorption and solubility testings (µg/mm³).

A. Water sorption (µg/mm³):

There was no significant difference between different groups ($f=2.01$, $p=0.144$). Group (I)

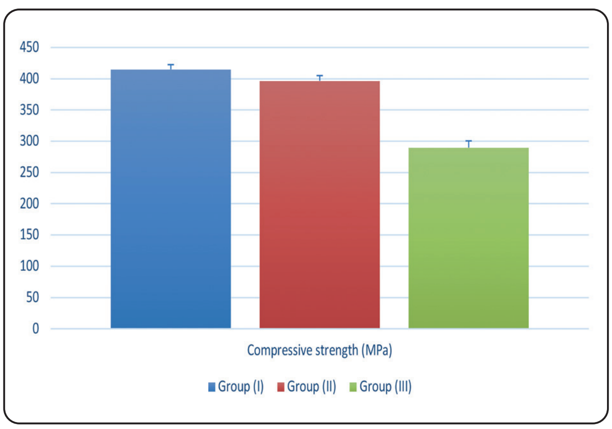

Fig. (1): Bar chart showing mean and standard deviation values of compressive strength (MPa) in different groups

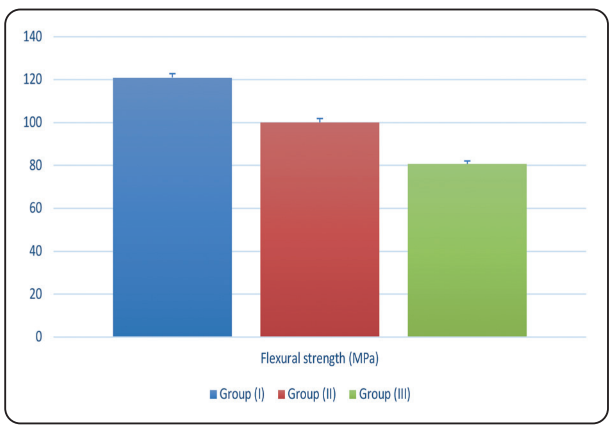

Fig. (2): Bar chart showing mean and standard deviation values of flexural strength (MPa) in different groups revealed water sorption value of 20.99±1.72 μg/mm³. Group (II) revealed 20.75±2.04 μg/mm³. Group (III) revealed 21.81±1.46 μg/mm³.

B. Solubility (µg/mm³):

There was a significant difference between different groups (f=14.80,p<0.001). The highest value was found in group (III) (3.03±0.34 µg/mm³), followed by group (II) (2.79±0.28 µg/mm³), while the lowest value was found in group (I) (2.53±0.24 µg/mm³). Post hoc pairwise comparisons were all statistically significant (p<0.001).

V- Results of color matching test between the tooth structure and Omnichroma restorative composite: Change in color (ΔE values) between the restoration and the surrounding tooth structure at different storage procedures.

There was a significant difference between values measured at different intervals (f=1989.83, p<0.001). The highest value was measured at group (III) (3.06±0.21), followed by group (II) (1.38±0.22), while the lowest value was found at group (I) (0.47±0.09). Post hoc pairwise comparisons were all statistically significant (p<0.001).

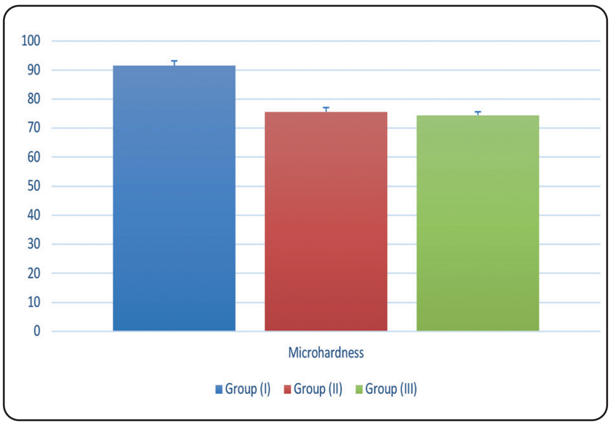

Fig. (3): Bar chart showing mean and standard deviation values of micro- hardness (VHN) in different groups

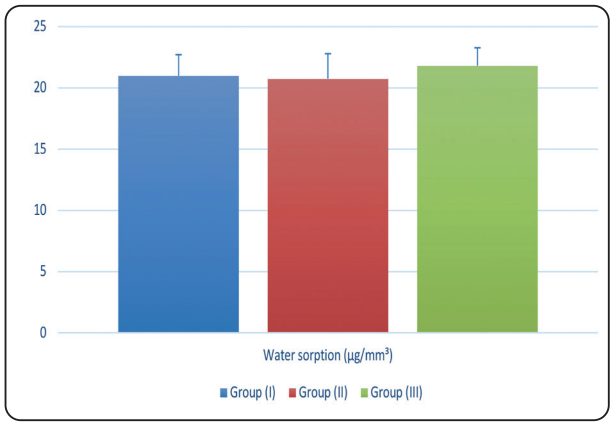

Fig. (4):Bar chart showing mean and standard deviation values of water sorption (µg/mm³) in different groups

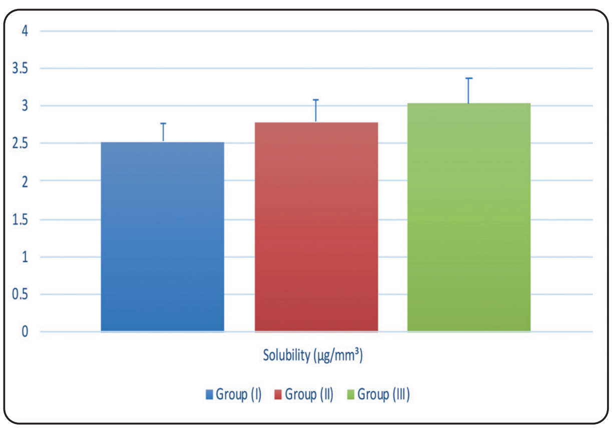

Fig. (5): Bar chart showing mean and standard deviation values of solubility (µg/mm³) in different groups

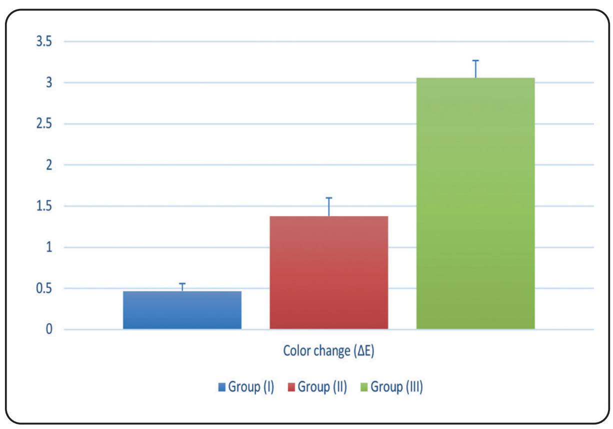

Fig. (6): Bar chart showing mean and standard deviation values of color change (ΔE) in different groups

Table (1): Intergroup comparisons for all tests.

Parameter	**(Mean±SD)**			**f-value**	**p-value**
	Group (I)	***Group (II)***	***Group (III)***		
Compressive strength (MPa)	414.92±7.67^{A}	396.75±8.28^{B}	289.84±10.79^{C}	**1123.67**	**<0.001***
Flexural strength (MPa)	121.05±1.74^{A}	100.03±1.85^{B}	80.72±1.36^{C}	**2938.84**	**<0.001***
Micro- hardness (VHN)	91.55±1.62^{A}	75.60±1.48^{B}	74.51±1.12^{C}	**901.64**	**<0.001***
Water sorption (µg/mm³)	20.99±1.72^{A}	20.75±2.04^{A}	21.81±1.46^{A}	**2.01**	**0.144**
Solubility (µg/mm³)	2.53±0.24^{C}	2.79±0.28^{B}	3.03±0.34^{A}	**14.80**	**<0.001***
Color change (ΔE)	0.47±0.09^{C}	1.38±0.22^{B}	3.06±0.21^{A}	**1989.83**	**<0.001***

Different superscript letters indicate a statistically significant difference within the same horizontal row.

****significant (p<0.05)***

DISCUSSION

An imperative challenge for producing a universal composite is to achieve the best possible translucency of the material; in order to approach the optical shade of tooth structure. This property was named the "Chameleon effect".[10] A new promising product that was introduced into the market in 2019 was Omnichroma; by Tokuyama Dental. This was the first composite resin restorative material that could match any tooth shade. The filler of the composite consists of specific single-sized spherical particles of 260 nm, which was mentioned by TOKUYAMA's researches to offer favorable light transmission behavior through the composite structure; so can generate color parameters more matching the surrounding natural tooth structure.[11]

Regarding Omnichroma; as it poses a unique property that may have an exclusively potential effect on esthetic dentistry; this research aimed to look into some properties of this material in an attempt to figure it out, and answer a proposed question of whether Omnichroma can revoke other resin composite restoratives or not.

For color assessment in this study the CIE Lab color system was applied. It is considered a highly recommended color measurement method for dental rationales. It showed greater simplicity and easier calculations over the CIEDE 2000 that accounts lightness as a much more sensitive parameter, but applies more sophisticated calculations.

One of the most accurate and widely used tools for measuring color is the spectrophotometer. It is considered a highly precise, simple and sensitive tool. Spectrophotometer is based on measuring the spectral reflectance or transmittance from a specimen. Comparing spectrophotometers to colorimeters revealed that spectrophotometers have a better ability to determine surface colors, and has high sensitivity for shade matching assessment at very low levels of light. Thus, in the current study, spectrophotometer was the tool of choice for color determination.

Criticizing the esthetic aspect of Omnichroma needs the understanding of two terms: perceptibility and acceptability. Perceptibility can be related to recognizing a perceptible difference, which is a psychophysical judgment of the observer denoting whether a difference in color is felt or not. In order to quantify this perceptible difference, a visual colorimeter can be employed, where in two halves of the bipartite field a color matched pair is seen by the observer. Observers are then asked to start changing the wave length of one of them, until a difference will just be noticed. This measure is obtained without any interpretation of human observers. On the other hand, acceptability judgment is another visual judgment regarding color difference. One thing that distinguishes it from perceptibility is that the observer interprets the color difference when it is detected. As soon as a batch of material is either accepted or rejected, this means that an acceptability decision is made. Thus, even if two pairs of colors show the same perceptibility, acceptability judgments can be different, noticing that the range of acceptability is higher than that of perceptibility. This was supported by a study conducted by Douglas and Brewer in 2003(12), employing porcelain fused to metal crowns, found that ΔE for acceptability was significantly greater than perceptibility. Literature data on perceptible and acceptable color differences are inconsistent. A previous study had reported that a ΔE of 0.3- 0.5 is the minimum color difference observable by the human eye, ΔE being 1.1- 2.1 is a perceptible but an acceptable threshold, and ΔE more than or equal to 3.3 is unacceptable.(13) According to other studies; ΔE less than 1 is imperceptible by the human eye, values of ΔE 1- 3.3 are perceptible but clinically acceptable, while ΔE more than 3.3 is clinically unacceptable.(14-16)

On pointing out the esthetic restorative material of choice; it is mandatory to evaluate some important mechanical properties that have a strong influence on the durability of the restorative material. One of the most important mechanical features is the compressive strength of the restorative material. Another laboratory test used to evaluate the mechanical quality of composite is the flexural strength testing. Three- point- loading flexural strength testing was conducted in the present study. This test represents the set of forces falling on a stress concentrated area; resulting in producing both tensile and compressive forces near the point of force application. Surface hardness of the material has a strong relationship with the resistance of the resin composite to intra-oral abrasive conditions. Thus, the present study included surface micro- hardness assessment of Omnichroma resin composite using Vickers hardness testing. As the durability of a resin composite restoration is highly affected by water sorption in the oral environment, it was found of highly crucial to assess water sorption and solubility of Omnichroma restorative composite and recognize their correlation with the mechanical and esthetic characteristics of the resin composite. To simulate the oral environment and assess the long term durability of Omnichroma composite, accelerated aging by thermocycling was performed and the mechanical properties, as well as water sorption and solubility were tested at 24 hours of preparation, after 5000 thermal cycles, and after 10,000 thermal cycles.(17)

By observing the results of the conducted study, the null hypotheses were rejected, except for water sorption assessment.

The tested mechanical properties showed deterioration by accelerated thermal aging. The compressive strength of Omnichroma composite showed a significant decrease when measured after 5000 thermal cycles (group II: 396.75±8.28 MPa) in comparison to that measured at 24 hours (group I: 414.92±7.67 MPa). Additionally, when measured after 10,000 thermal cycles (group III), the compressive strength revealed a significant decrease resulting in 289.84±10.79 MPa. This could be attributed to chemical degradation of composite that might have occurred under the influence of water sorption and thermal fluctuations. Degradation of dental resin composite occurs due to two main reasons; the first is water diffusion through the resin matrix causing hydrolytic degradation and plasticizing effect. The second is the thermal fluctuations that result in thermal stresses within the composite resin. Accumulated thermal stresses and hydrolysis of the resin matrix can result in minute microcracks, which seemed to be associated with reduced compressive strength of the resin composite. This could reveal the questionable resistance of material to clinical in service factors as thermal changes and humid environment, and could affect color matching by time. Statistically, the difference in compressive strength was more observed on comparing group III to group II than on comparing group II to group I. This could be attributed to the counteracting effect of increased degree of conversion that might have taken place at the first duration of thermocycling (5000 thermal cycles), inducing a work against the plasticizing effect and hydrolytic degradation of water sorption. However, at 10,000 thermal cycles (the second duration of thermocycling) might not have shown change in the degree of conversion of the composite resin, and accordingly the deteriorating effect of thermal aging and hydrolysis were more prominent. This postulation was in line with Ghavami-Lahiji et al.(2018) [18] who mentioned in their study that the degree of conversion of microhybrid Filtek Z250 showed an increase up to 4,000 cycles, further thermocycling from 4,000 to 10,000 cycles did not significantly alter the degree of conversion. The reason may be continuation of the polymerization reaction of entrapped unreacted monomers, where increasing temperature can enhance the diffusion reaction, making the radicals able to react with any remaining double bonds within the network and continue the polymerization process.

Flexural strength showed significant decrease with thermal aging from 24 hours (121.05±1.74 MPa) to 5000 thermal cycles (100.03±1.85 MPa), and also furthermore significant deterioration from 5000 thermal cycles to 10,000 thermal cycles (80.72±1.36 MPa). In contrary to the compressive strength, the differences in flexural strength was statistically comparable on comparing group III to group II, also on comparing group II to group I. This can indicate that the sensitivity of flexural strength to thermal aging was more than the compressive strength, and could be attributed to the influence of the produced thermal stresses within the composite specimens. These accumulated stresses with the hydrolytically degraded resin matrix can intensify the effect of tensile stresses created at the area of bending (the weakest point), which might have a stronger detrimental influence on the tested composite specimens when tested by three point loading compared to that if tested under compression.

By comparing the results obtained by the present study to that conducted by Oregon Health and Science University.[19] The study offered by Oregon Health and Science University and was mentioned by the manufacturer as foundation for Omnichroma resin composite evaluation. Oregon Health and Science University had mentioned that the compressive strength of Omnichroma was 317.21 MPa and the flexural strength was 110 MPa. The manufacturer demonstrated these results to be clinically acceptable records. As observed in that study; the assessed properties were measured at 24 hours of storage; however no long term assessment was performed. On the other hand, the present study offered the assessment under the influence of accelerated aging as an alternative to long term clinical assessment.

Regarding the surface micro-hardness, a significant decrease in VHN of Omnichroma resin composite was observed under the influence of thermocycling for 5000 cycles (group II: 75.60±1.48 VHN) when compared to that measured at 24 hours (group I: 91.55±1.62 VHN). Also, a significant decrease was found on comparing the measured micro- hardness at 10,000 thermal cycles (group III: 74.51±1.12 VHN) to that at 5000 thermal cycles. Nevertheless, it should be noticed that the difference in micro-hardness was more pronounced on comparing groups I to group II than on comparing group II to group III, in opposing to the compressive strength results. This could be attributed to the early greater influence of thermal fluctuations and humid environment on surface properties of resin composite than influencing their bulk structural characteristics, resulting in lowering the surface hardness at the first duration of thermal aging (5000 cycles) than that occurred at the second aging duration that was represented in the 10,000 thermal cycles. Water sorption occurs by the resin composite causes plasticization of the resin matrix. Accordingly, softening of the specimens' surface took place earlier than the degradation of the bulk structure. The decreased surface hardness by accelerated aging can reveal an unsatisfactory resistance of Omnichroma resin composite to the humid and thermally fluctuating oral environment, and can result in lowering the wear resistance of the composite restoration, with high susceptibility to scratching and indentations. Consequently, this can render the restoration more prone to staining by stains and artificial pigments in food and drinks, and so can counteract the distinctive esthetic feature of Omnichroma on long term intraoral service.

All mechanical properties should be correlated to water sorption and solubility, because solubility and disintegration of composite can be a causative factor for mechanical degradation, as well as esthetic deterioration of the resin composite. Omnichroma dental resin composite showed water sorption by 20.99±1.72 μg/mm^3, 20.75±2.04 μg/mm^3 and 21.81±1.46 μg/mm^3 when measured for groups I, group II, and group III respectively. Solubility results were 2.53±0.24 μg/mm^3, 2.79±0.28 μg/mm^3, and 3.03±0.34 μg/mm^3 for groups I, group II, and group III respectively. In accordance to the ISO standards, these values are accepted, as it was mentioned by ISO standards 4049:2019[6] for dental restorative resins that the maximum acceptable value of water sorption is 40 μg/mm^3, and that for solubility is 7.5 μg/mm^3. No significant change in water sorption was detected between the tested groups. On the other hand, solubility results revealed a significant increase in solubility between the tested groups. Water molecules can penetrate the polymer network, allowing the diffusion of uncured monomers from the material structure. This can denote the high susceptibility of Omnichroma resin composite to evident solubility on long term service. Despite the accepted values of water sorption and solubility, still they could be considered powerful reasons for the deteriorated mechanical properties measured after thermocycling, and could reveal the probability of losing the peculiar feature of shade matching of Omnichroma by the effect of the intraoral environment, especially on long term service.

Concerning the shade matching assessment of Omnichroma composite resin restorative material; the manufacturer relied upon a study that was conducted by Nihon University School of Dentistry [20] to examine the color-matching ability of Omnichroma compared to other resin composites known to show a chameleon effect: (Estelite sigma quick, and Filtek supreme ultra). Among the resin composites tested in that study; Omnichroma demonstrated minor ΔE values of 1.9 to 3.2 for all teeth and restoration depths, compared to Estelite sigma quick and Filtek supreme ultra which revealed Δ E values in the range of 2.9 to 15.4 and 2.6 to 13.4, respectively. Nihon University study demonstrated that Omnichroma's ability to reproduce a wider range of teeth color via structural coloration technology, making it the only tested composite with clinically acceptable results for all specimens. The study was mentioned by the manufacturer to demonstrate the great success of Omnichroma in matching the surrounding tooth structure. By criticizing that study; it lacked the assessment of long term storage or accelerated aging effect on color parameters of Omnichroma resin composite. On the contrary, the present study went through testing the color parameters and shade matching of Omnichroma resin composite at different accelerated aging thermocycles in order to offer a more reliable assessment.

The findings of the present study revealed that the mean value of ΔE for specimens of group I was 0.47±0.09. This revealed that it had fallen within the accepted range mentioned by CIE Lab [21]; since the visually perceptible ΔE value was described to be more than1.8- 2. Concerning the mean value of ΔE for specimens of group II; it was 1.38±0.22, which was also acceptable according to the CIE Lab, despite the significant difference found when comparing results of group II to those of group I. This reflects that the Omnichroma restoration/ tooth shade matching could be kept within the range of visual acceptability if subjected to thermocycling up to 5000 cycles, which is clinically equivalent to approximately a period of about 6 months of intraoral service. Concerning the mean value of ΔE for group III; it was found to be 3.06±0.21. According to the CIE Lab, this value can be considered a border line with the visual acceptability range, as it was just below 3.3, which is considered the border of the accepted ΔE value [16-18]. This denotes the possibility of revealing a shade mismatching that is visually unacceptable, on long term service of Omnichroma composite restorations, especially on considering the assaults of absorbed colorants from staining solutions of food and drinks. In the present study it must be considered that thermocycling process was performed in water that lacks any pigments. This test might have lead to different results if was performed in staining solutions.

Significant changes in color matching that occurred by thermal cycling can be a response to water sorption and solubility of the resin composite, with a confirmed relevance to the results of mechanical properties tested in the current study. This finding could be related to the hydrophilic nature of the resin matrix of Omnichroma composite that can induce a considerable degree of water sorption, and so it would be more subjected for absorbing other fluids. Water sorption may decrease the life of a resin composite by causing plasticization of the resin component, hydrolyzing the silane coupling agent, and causing micro-crack formation. As a result, the microcracks within the composite structure or interfacial gaps at the interface between the filler and matrix can cause light dispersion within the material structure, leading to decreased translucency that resulted in significant change in shade matching. In addition, if the composite would be subjected to staining solutions, these microcracks and interfacial gaps can allow stain penetration as water is the pigment carrier. The solubility of the resin composite that was confirmed by the study, aided by the thermal fluctuations could consequently result in composite degradation and structural breakdown particularly on the long run. The anticipated hydrolysis, in conjunction to the thermal degradation are powerful opponents to shade matching persistence of the resin composite material with the tooth structure on long term clinical service.[22]

On comparing the results of the present study to a previously conducted study by Abdelhamed et al.(2022)[23], who evaluated the durability of optical properties of Omnichroma and Essentia composite (Chameleon composites), thermocycled in black dark drinks for 2500 and 5000 cycles. The study revealed that color durability of Omnichroma (supra-nano) versus Essentia composite (hybrid micro-nano type) was negatively affected in dark drinks after 3 and 6 months. Thermocycling in dark drinks showed an adverse effect on color stability of both selected chameleon composite types. The results of the study conducted by Abdelhamed et al. were in line with the results obtained from the present study. Although the present study lacked the effect of staining solutions that were used in Abdelhamed et al., it had offered wider information about aging of Omnichroma composite; being extended to 10,000 thermal cycles, in contrary to Abdelhamed et al. that performed their study at 2500 and 5000 thermal cycles.

To answer the proposed question ***"Can Omnichroma dental resin composite revoke other restorative composites?"*** According to the present study, Omnichroma resin composite restorative material cannot be considered as a single composite that can revoke other composite restoratives. Still needs strengthening and modifications to aid it to resist long term degradation, particularly during clinical service in order to keep its characteristic property of matching the surrounding tooth structure. Assessment of color parameters of Omnichroma resin composite as influenced by different stains in food and beverages is highly required to be sufficiently covered in the scientific research. Long term clinical assessment of Omnichroma restorations is greatly needed; in order to perform a reliable judgment of this resin composite material.

CONCLUSIONS

Within the limitations of the present study, the following could be concluded:

1- Accelerated aging by thermocycling can cause deterioration in compressive strength, flexural strength and micro- hardness of Omnichroma dental resin composite, proving the necessity for performing remarkable comprehensive trials to improve its mechanical properties.

2- Subjecting Omnichroma dental resin composite to thermocycling up to 10,000 cycles may not affect water sorption; however a significant increase in solubility can occur by thermocycling.

3- Shade matching of Omnichroma to the surrounding tooth structure can be adversely affected by thermocycling. At 10,000 thermal cycles the color change (ΔE) may reach the border range of clinical acceptability, denoting the doubtfulness of shade matching permanence.

4- In case of demanding Omnichroma as a long term stable single shade restorative composite, it is mandatory to recognize the correspondence of its esthetic characteristics to its mechanical properties, as well as its hydrothermal behavior.

Recommendations

Omnichroma dental resin restorative composite still needs more in- vitro and in- vivo studies concerning the effect of stains in food and drinks on shade matching permanence. Ph fluctuations and effect of acids on Omnichroma composite microstructure is a pivotal aspect to be assessed and correlated to its mechanical and esthetic characteristics. In addition, its wear resistance is important to be assessed at different aging durations. Studying the microstructural changes occur to Omnichroma composite as affected by thermocycling, as well as water sorption and solubility should be also considered and correlated to various mechanical and esthetic properties.

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Conflict of interest

The author declares no conflict of interest.

Ethical approval

This study was conducted in accordance to the guidelines and policies of the Ethics Committee, Faculty of Dentistry, Ain Shams University. The approval code for this study was: FDASU- Rec IR072204.

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