Original Article

An *in vitro* comparative evaluation of commonly consumed catechu and catechu with lime on surface roughness and color stability of the conventional nano-hybrid composite

Dhaval Bhadra, Nimisha C. Shah, Karkala Venkappa Kishan, Meetkumar S. Dedania

Department of Conservative Dentistry and Endodontics, K. M. Shah Dental College, Sumandeep Vidyapeeth, Vadodara, Gujarat, India

Abstract

Aim: Comparative evaluation of commonly consumed catechu and catechu with lime on surface roughness and color stability of the conventional nano-hybrid composite.

Methodology: A total of 50 uniform cylindrical disks of 10-mm diameter and 2-mm thickness prepared from the nano-hybrid composite were used in the study. Each sample was randomly divided into three subgroups of 20 samples each in two experimental groups (catechu, catechu, and lime) and 10 samples in the control group (artificial saliva). The samples were immersed in each agent for 15 days. Surface roughness and color changes measurements were noted at the baseline and 15th day by two-dimensional profilometer and spectrophotometer, respectively.

Results: It was found that nano-hybrid composite resin showed more surface roughness and color change when immersed in catechu and catechu with lime as compared to the control group. Intergroup comparison showed statistical significant increase in surface roughness and color change in the catechu group followed by the catechu with the lime group and artificial saliva.

Conclusion: Within the limits of the present study, it can be concluded that all experimental specimens showed discoloration. At the end of 15th day, among the groups, catechu showed more surface roughness and color change followed by the catechu and lime and the control group.

Keywords: Catechu; lime; nano-hybrid composite; profilometer; spectrophotometer

INTRODUCTION

Esthetics has played a major role in the field of dentistry and its development and research. The trend toward a natural look has paved the way for the development of tooth-colored restoratives that simulates the tooth as closely as possible.[1]

Esthetic failure is one of the most common reasons for the replacement of the restorations. Color changes in resin composites occur from intrinsic and extrinsic factors. Intrinsic factor depends on the composition of the resin matrix, the type of bonding between the filler and matrix, etc., Extrinsic factors such as adsorption or absorption of extrinsic stains pose a major problem for esthetic restorations. Erikson *et al*. suggested that retention of the colored substances from dietary constituents significantly contribute to the formation of extrinsic stains.[2-4]

Certain unique topographic patterns are observed with respect to the consumption of addictive substances in India, with paan (betel nut leaf) being a highly consumed thing

Address for correspondence:
Dr. Nimisha C. Shah, Department of Conservative Dentistry and Endodontics, K. M. Shah Dental College, Sumandeep Vidyapeeth, Piparia, Vadodara, Gujarat, India.
E-mail: nshah7873@gmail.com

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in India, in various forms and compositions. Furthermore, there is a higher consumption of katha (catechu) and lime in the betel nut leaf preparation. This consumption rate of betel nut leaf has been shown to have a drastic statistical value in the South Asian countries. However, the rate is extremely higher in India and the Indian subcontinent.[5]

Consumption of these products may affect the esthetic and physical properties of the resin composites thereby undermining the quality of restorations. The chemicals in them can lead to wear and surface degradation of composite restorations resulting in unesthetic external pigmentation such as stains.[6]

Hence, nano-hybrid composites are considered to be the gold standard materials as posterior restorative material. Still one of the properties of the composite resins that have to pass the test of time is its color stability. In modern day dentistry, a large emphasis is laid over esthetics. Surface staining occurs in nano-hybrid composite due to the oxidation of tertiary amines accelerator which causes a change in hue from whitish-to-yellowish appearance. Color stability is directly proportional to the surface roughness of the composite restoration. Increased surface roughness can lead to greater plaque retention and stain absorption than relatively smoother surface. Catechu itself bearing a strong color and being in a close association of the restoration can lead to staining. There have been studies demonstrating the effect of beverages and other foodstuffs as well as cigarette smoking on composite resin; however, there is no literature till date on the effect of catechu and lime on the composites.[7,8]

Hence, the present study aims to evaluate the effect of commonly consumed catechu and catechu with lime on surface roughness and color stability of the conventional nano-hybrid composite resins.

The null hypothesis is there will be no change in the surface roughness and color stability of the nano-hybrid composite at the end of 15 days after they are immersed in catechu and catechu with lime.

METHODOLOGY

After obtaining the ethical approval, 50 composite discs of 10 mm in diameter and 2 mm in width were prepared using nano-hybrid composite (Solare X, A2 Shade, GC, Tokyo, Japan) with the help of Teflon molds placed on a clean glass slab covered on both sides by cellophane strip to provide uniform thickness and texture. The discs were polished using composite polishing disc (Shofu, Tokyo, Japan). They were then randomly divided into three groups. Group 1 ($n = 20$) catechu, Group 2 ($n = 20$) catechu with lime, and Control group ($n = 10$) artificial saliva. The test agents were prepared using the dilution method. It contains an aqueous solution of the catechu powder. The primary solution was made by using the ratio of 4:1. The measuring quantity was 2.5 g of catechu in 10 mL of water. This solution was boiled and then allowed to cool at the room temperature, and then 2 mL of water was added with continuous stirring to make the primary solution. To prepare the agent for Group B, lime was added to the primary solution in the ratio of 2.5:1 with continuous stirring until a creamy homogenous formulation is obtained, and the prepared final formulation was used for the study. The discs were then immersed in the agents for 10 min twice daily for 15 days, and the discs were then removed and stored in distilled water at 37ºC and 100% humidity in an incubator. The surface roughness and color change for all the samples were assessed using two-dimensional profilometer and spectrophotometer, respectively, for baseline and 15 days. For surface roughness, each specimen was washed and blotted. The roughness was measured using a profilometer, with 2-mm tracing length and a −0.25-mm cut-off value and a tip of size 0.01 mm, in three different locations, and the average roughness was calculated. At the time of color measurements, the samples were removed from the test solutions, dipped in the distilled water, wiped with the tissue paper, and placed on a thermocol platform with a slot in which study samples were placed. The platform also had a slot for the spectrophotometer used for the color measurement. The spectrophotometer was calibrated by measuring against standard white background provided by manufacturer, a process known as zeroing. The readings were taken under the illumination of D50 which was equal to natural daylight. The spectrophotometer software calculates the color measurement using following formula: $(\Delta E) = (\Delta L^2 + \Delta b^2 + \Delta a^2)^{1/2}$, in which L-lightness of color and ranges between 0 (dark) and 100 (White), a-color on red-green axis, and b-blue part of the color. The data were then collected and analyzed statistically using SPSS Software version 18.0 (IBM SPSS Inc, Chicago, IL).

RESULTS

One-way ANOVA test revealed, both surface roughness and color changes showed a statistically significant difference ($P < 0.001$) between the baseline and at the end of 15th day. There were a greater color change and surface roughness observed in Group 1 as compared to that of the Group 2 and minimal changes observed in the control group [Table 1].

Tukey's *post hoc* test revealed a statistically significant difference in surface roughness between Groups 1 and 2 ($P < 0.001$), Group 1 and control group ($P < 0.001$), and Group 2 and control group ($P < 0.001$). It also showed a statistically significant difference in color change between Groups 1 and 2($P < 0.001$), Group 1

and control group ($P < 0.001$), and Group 2 and control group ($P < 0.001$) [Table 2].

DISCUSSION

Esthetics in the 21st century has played a major role in dentistry. The trend toward a natural look has paved a way for the development of new restorative composite resin. The newer composite system provides with better mechanical and optical properties making possible more artistic approach.[1] Esthetic failure is one of the most common reasons for the replacement of restorations. Major problems associated with esthetic restoration are marginal staining, marginal bond failure, and accumulation of the plaque, surface roughness, and mainly color changes of the esthetic restoration.[9]

Nano-hybrid composite combines the properties of earlier hybrid and microhybrid composite. Nano-hybrid composite has improved mechanical properties, i.e., better compressive strength, diametrical tensile strength, fracture and wear resistance, low-polymerization shrinkage, high translucency, and high-polish retention.[8] Hence, nano-hybrid composite is considered to be the gold standard material as posterior restorative material. However, the problem with nano-hybrid composite is surface staining and color stability.[10] Externally-induced discolorations are due to the consumption of common food items, beverages, or certain items pertaining to the habits such as paan (betel nut), gutkha, or tobacco. The staining agents catechu and catechu with lime that are selected for the study are common ingredients of paan preparation, that is, consumed very commonly in India and the Indian subcontinent and also has the potential for discoloration of the restorative material.[9]

The term catechu refers to a raw material, that is, useful in making dyes and in tanning. Black cutch or catechu is the source of an important brown dye. It is from the heartwood of Acacia catechu, a tree native to Burma and India. Wood pieces are boiled in water and the extract is evaporated to a purple-black, gummy, and semisolid-mass, that is, then molded into the blocks. This is a fast dye and it is used for the different shades of fawn, brown, olive, and drab colors, including khaki. Catechu is also used in medicine and as a masticatory. Black catechu has recently also been utilized by Blavod Drinks Ltd., to dye their vodka black.[11,12]

Calcium hydroxide (traditionally called slaked lime) is an inorganic compound with the chemical formula $Ca(OH)_2$. It is a colorless crystal or white powder and it is obtained when calcium oxide (called lime or quicklime) is mixed, or slaked with water. It has many names, including hydrated lime, caustic lime, builders' lime, slack lime, cal, or pickling lime. Calcium hydroxide is used in many applications, including food preparation. Limewater is the common name for a saturated solution of the calcium hydroxide. Being a good digestive, it has been used in betel nut preparation (paan) in combination with areca nut and catechu.[13]

Various beverages such as coffee, wine, Coca-Cola, and tea have been tested for color change and surface roughness of the composite resin, but catechu an active ingredient in the preparation of paan (betel nut) has never been tested for the same, and hence there is no standard preparation available in the literature, hence the preparation used in

Table 1: One-way ANOVA of surface roughness and color stability

	n	Mean (base-line)	Mean (15th day)	SD	SE	Minimum	Maximum	ANOVA *P*
Surface roughness								
Group 1	20	0.43	2.09	0.13	0.030	1.83	2.32	<0.001
Group 2	20	0.44	1.84	0.08	0.018	1.71	1.95	
Control	10	0.42	0.49	0.04	0.014	0.44	0.53	Not significant
Color stability								
Group 1	20	34.70	46.56	2.32	0.519	42.63	52.78	<0.001
Group 2	20	34.63	41.82	1.43	0.320	39.18	43.99	
Control	10	34.52	34.71	0.94	0.298	32.23	35.61	Not significant

SD: Standard deviation, SE: Standard error

Table 2: *Post hoc* test of surface roughness and color stability

	Post hoc test						
	Type (I)	Type (J)	Mean difference (I−J)	SE	*P*	95% CI	
						Lower bound	Upper bound
Surface roughness	Control	Group 1	−1.60	0.039	<0.001	−1.69	−1.50
	Control	Group 2	−1.34	0.039	<0.001	−1.44	−1.25
	Group 1	Group 2	0.25	0.032	<0.001	0.18	0.33
Color stability	Control	Group 1	−11.67	0.712	<0.001	−13.39	−9.95
	Control	Group 2	−7.00	0.712	<0.001	−8.72	−5.28
	Group 1	Group 2	4.67	0.581	<0.001	3.26	6.08

SE: Standard error, CI: Confidence interval

this study follows the common method of preparation of catechu for paan in India.

An average consumption of an individual in India is about 2–3 in a day that accounts to roughly about 10 min in one time. Hence, the samples were immersed for 10 min twice a day.[14]

Color stability is also dependent upon the surface roughness of the composite restoration, as increase in surface roughness may lead to greater plaque retention which leads to discoloration.[15,16] Surface roughness of the composite can reduce some mechanical properties such as hardness and increase the wear of restoration. The surface properties of the composite resin also depends on chemical composition of the agents, the type of acid present and the potency of individual acidic ingredients. However, pH of the staining agent also plays an important role in surface degradation of the composite material.[17]

The staining observed in this study are those that occur on the surface. This is because of the hydrophobic dimethacrylate-based monomers in nano-hybrid composite resins. It was found that the incorporation of greater amount of TEGDMA resulted in an increase in water absorption in Bis-GMA-based resins.[4]

The reason for the increased color change and surface roughness in catechu group may be attributed to the composition of the material that showed the presence of the acid and other phenolic compounds. Catechu is composed of 13%–33% of crude catechin, also called catechuic acid, and from 22% to 50% of a peculiar tannic acid, called catechu-tannic acid. Besides, these other compounds present are pyrocatechin. The acids bear a relative pH of around 3–4 that might be the reason for the dissolution of the resin matrix leading to water sorption and surface roughness further leading to color changes.[18] Lime is a calcium-containing inorganic mineral in which carbonates, oxides, and hydroxides predominate. In the strict sense of the term, lime is calcium oxide or calcium hydroxide. pH of the lime is around 11.8–12.4. Hence, on interaction with acid lime increase the pH, hence reducing acidity and increasing alkalinity. Limewater turns milky in the presence of carbon dioxide due to the formation of calcium carbonate, a process called carbonation. Hence, when an acid is added to calcium carbonate, hydrogen from the acid reacts with the carbonate and forms carbonic acid that will decompose of to form carbon dioxide which will eventually bubble off in the atmosphere and the water will be left thus reducing the acidity.[12]

Hence, the null hypothesis was rejected. There was a statistical difference between the color stability and surface roughness of the catechu group and catechu and lime group.

As it is *in vitro* study, it is difficult to extrapolate the result of this study to *in vivo* conditions. Furthermore, the agents used in this study were used alone where as they are consumed in combination with areca nut, betel leaves, and various other constituents which might affect the results.

However, there are no studies and a very scarce literature available about the effect of catechu or lime on composite resins. The literature has widely revealed the potential effects of certain food items and beverages on composite resins' surface characteristics affecting the clinician's choice of material and the patient's control of dietary habits, but there is no report on whether or how the catechu or lime affects composite resins. Further, *in vitro* studies and clinical trials are needed to be conducted to give a more thorough understanding of the effects of these agents on composite resins' surface properties and to assure better color stability and long-term maintenance of the restorations.

CONCLUSION

1. Within the limitations of the present study, it can be concluded that all specimens showed discoloration after the completion of the test period which was visually perceptible and clinically unacceptable
2. Comparing within the test solutions, catechu has shown more surface roughness than catechu with lime and the control group at the end of 15 days
3. Comparing within the test solutions, catechu has shown more color change than catechu with lime and control group at the end of 15 days
4. Hence, it should be noted that the patients should be made aware about the staining characteristics of the catechu in the betel leaf preparation on tooth-colored restorations. Furthermore, clinicians should take every possible measure to minimize other contributing factors such as complete polymerization, incomplete finishing, and polishing of the composite resins. All these, in turn, will help in prolonging the color retainability of the tooth-colored restorative materials.

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Conflicts of interest
There are no conflicts of interest.

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