A STUDY ON EVALUATION OF SURFACE ROUGHNESS AND ANTI-STAINING PROPENSITY OF NANO-COMPOSITE DENTURE TEETH

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ABSTRACT

Background and Objective: The introduction of nano-filled resin systems has resulted in considerable controversy. Lack of evidence-based scientific information and unavoidable time lag in establishing the precise relationship between their physicomechanical properties and clinical performance sought us to substantiate and qualify relative surface roughness and anti-staining characteristics of three commercially available type of artificial teeth.

Materials and Methods: Three brands of three types of artificial teeth were examined. The staining behavior of the artificial teeth after immersion in tea solution for one hour was evaluated by spectrophotometric analysis. Qualitative SEM analysis was used to assess the surface appearance after treatment with 2% citric acid for four hours.

Results: The difference in mean optical density values for unstained and stained specimens suggested least staining with nanocomposite among the combinations used. Examined teeth when subjected to citric acid retreatment showed no qualitative surface changes in nano and microfilled composite but significant surface alterations were observed in dual cross-linked acrylic teeth.

Conclusion: Within the limitations of this study, Nano composite showed significantly improved surface smoothness and stain resistance when compared to microfilled composite and dual cross-linked teeth tested.

Keywords: Nanocomposite denture teeth, surface finish, stain resistance, scanning electron microscope, spectrophotometry.

INTRODUCTION

Artificial teeth are often necessary for prosthodontic rehabilitation when natural teeth are lost. Acrylic resins and porcelains have been used for the fabrication of artificial teeth; however, neither type completely accomplishes the requirements for an ideal prosthetic tooth. It is well known that some dietary factors, such as tea lead to extrinsic tooth discoloration. Also citric acid, an organic acid found in high percentages in many dietary supplements, cause dental erosion and produces surface roughness of denture teeth. Its been observed that during wear of resin composite teeth, inorganic fillers debond from the resin matrix and leave a void, increasing the surface roughness and forming a surface susceptible to exterior stain. The amount of filler content, the geometry and size of the filler particles, and the properties of the polymer matrix have been reported to influence the properties of
polymer materials. A new type of denture tooth, fabricated of nano-composite resin, has recently been developed as a highly polishable, stain and impact resistant material.

Few laboratory tests have been able to substantiate and quantify the surface roughness and anti staining property of polymeric denture teeth. Also, evidence-based scientific information regarding these new types of artificial teeth with respect to composition and physicomechanical properties is lacking. Therefore, studies critically discussing latest peer-reviewed reports and evaluating properties of commercial artificial teeth become necessary.

MATERIALS AND METHODS
Three groups of teeth (dual cross-linked acrylic resin, microfilled composite resin & nanofilled composite resin) were analysed for study.

SURFACE ROUGHNESS ANALYSIS
Preparation of samples and methodology for surface roughness evaluation
Fourteen specimens of maxillary central incisors from each type were used for SEM analysis using the sophisticated Scanning Electron Microscope (SEM). (JEOL, JFC - 1100E, Hitachi, High-Technologies Corp, Tokyo, Japan). After vapor-coating with gold by ion sputtering device, the untreated incisal surfaces were examined in the SEM with the back-scattered electron images under high magnification of 1000x operating at 20Kv. Subsequently, these specimens were soaked in 10ml of 2% citric acid solution for 4 hours (assuming that average exposure is 40 sec. per day, thus simulating 1 year of exposure). This was followed by qualitative SEM analysis to assess the surface appearance of the resultant acid treated specimens.

STAIN RESISTANCE EVALUATION
Specimen preparation
Fourteen specimens of maxillary 2nd molar from each type were used for stain resistance evaluation. Perspex strips of dimension 5x1 cm were prepared and maxillary 2nd molar was mounted at a height of 2.5 cm at an angulation of 45 degrees such that occlusal surface facing outward direction. This was the standardized guideline followed for specimen preparation such that focus of UV-Light of spectrophotometer is identical in position and location for all the specimens to be evaluated.

Tea Solution Preparation
100ml of double distilled water was taken in a beaker & allowed to boil. After that 1gm of green tea leaves (Elixir, rohini estate, Darjeeling), measured in electronic balance, were brewed for 5 min. As temperature affects staining reaction (Addy et al, 1985) so, experiment was planned to be conducted at room temperature. The tea solution was cooled to room temperature and filtered with Whitman filter paper no.6.

Wavelength Selection
Absorbance decreases gradually from 360nm to 600nm wavelength. At 360nm absorbance of unstained specimen at constant stable position, optical density was 0.513 and at 600 nm, it was 0.153. Since 360-370 nm wavelength is the transition zone, so we opted for 395nm wavelength as the dominant wavelength showing peak absorbance of 0.418.

Method of Data Collection
Optical density of each of the unstained forty two specimen at selected wavelength of 395nm was noted. Then, all the forty two specimens were immersed in freshly prepared tea solution for 60 minutes & later on washed with distilled water for 30sec & bench dried. Stained dried specimens were then subjected to spectrophotometer UV-light at same constant stable position and wavelength. Optical density of dried, stained specimens was noted and difference in the optical density of the specimens, before and after staining, was taken as a criteria to measure stain resistance. Lesser the difference, more the stain resistance.

Statistical technique used
ANOVA One way analyses of variance were used to test the difference between groups. To find out
which of the two groups means is significantly
difference scheffe’F’ test is used.

RESULTS
Surface Roughness Analysis
Qualitative Assessment as shown in figure 1, 2, 3
• The SEM image of untreated nanocomposite
tooth surface shows the small angular splintered
nano-filler complexes of various sizes
distributed in the matrix. While on other hand,
SEM image of 2% citric acid treated nano-
surface looks like the mirror image of untreated
one, depicting the excellent surface smoothness
even after one hour of citric acid treatment.
• In case of microfilled composite, untreated tooth
surface analysis shows angular and
spherical prepolymerised microfiller complexes
incorporated in organic matrix. Whereas for the
treated surface, SEM image shows no
topographic changes suggestive of no significant
alterations in the surface smoothness.
• Untreated Dual cross-linked acrylic SEM images
shows macrofillers of various sizes of identical
or different composition admixed in organic
matrix of Urethane Dimethacryl (UDMA). But
here in this case, noticeable difference was seen
on surface treatment with citric acid and
prominent surface irregularities were seen,
indicative of certain qualitative changes in the
surface topography debarring the surface
smoothness.

Stain Resistance Evaluation
Table 1 shows the calculated mean and standard
deviation of optical density of unstained and
stained specimens among three groups. With tea,
least staining was seen with nanocomposite
while minimum stain resistance was shown by
Dual Cross linked Acrylic (DCL) specimen
teeth, although data may vary depending upon
evaluation designs. The difference in mean
absorbance value (optical density) of three
groups exist on account of material
composition & homogenity.

DISCUSSION
New materials, even if they are proved excellent,
often have one or the other limitation, because
they may be associated with a re - evaluation of
the established systems of use and may not
readily be amenable for use. Furthermore, there is
an unavoidable time lag in establishing the precise
relationship between their properties and clinical
performance. Thus, the introduction of nanofilled
resin systems has led to considerable controversy,
both from the standpoint of the dentist and within
the scientific community. However, it is possible
to evaluate newer composite resins systems on the
basis of their microstructure.

Earlier researchers and manufacturers have
reported that nano-composites were made up of
homogenous urethane organic matrix reinforced
by heterogeneous, pre-polymerized silica
fillers. While the micro-filled composite
denture teeth (Endura) are heterogeneous, micro-
filled composite resins with agglomerated micro-
fillers are similar to traditional macro-filled ones
in size and chemistry, but not in structure. Further,
they allow a substantial increase in the micro-filler
content when admixed to an organic matrix. Such
a resin composite has been known to demonstrate
excellent finishing and perfect surface qualities.
However, not much is known about the in vivo
performance of composites with nano fillers.
Consequently, available property data on these
composite materials is rather limited. The absence
of such vital data was the basis for taking up the
study reported here.

Results of this study clearly indicate that the
hybrid (especially the nano-filled) resin
composites are markedly superior to the traditional
composites and acrylic resins in terms of surface
smoothness and anti-staining tendency. Further, as
the filler particle size is reduced, the polishability,
permanence of surface smoothness, and esthetics
of the nano-filled composites improve.
CONCLUSION
Judging by these results, it can be authentically concluded that nano-composite denture teeth may be one of the most promising and appropriate materials for denture teeth in near future. However, further investigation of other characteristics such as wear, impact resistance, and bonding to reparative autopolymerizing resins should be performed.

ACKNOWLEDGEMENT
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Conflict of Interest
None declared

REFERENCES

Table I: Mean and Standard Deviation of Optical Density Among Three Groups Before and After Immersion In Tea Solution

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<th></th>
<th>N</th>
<th>Mean</th>
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<th>Minimum</th>
<th>Maximum</th>
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<th>‘p’ Value</th>
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<td>Nanocomposite (NC)</td>
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Figure 1: Nano-composite tooth specimen

Figure 2: Microfilled composite tooth specimen

Figure 3: Dual cross linked acrylic tooth specimen