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CONGRESS PROCEEDING

Colour stability of different denture teeth stored in various beverages

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Abstract

Purpose: New types of denture teeth using modified acrylic resin that incorporate cross-linking agents and composite resin containing different types of filler have become increasingly common. It has been possible to produce nano-sized filler particles with nanotechnology. However, evidence-based information regarding composition and properties is lacking. The purpose of this study was to evaluate the colour stability of four commercially available denture tooth materials with different chemical structure when subjected to various beverages.
Materials and Methods: : Conventional acrylic resin (Major Dent, Major Prodotti Dentari S.p.A., Moncalieri, Italy), reinforced acrylic resin (Integral, Merz Dental GmbH, Lütjenburg, Germany), microfiller composite resin (SR Orthosit PE, Ivoclar Vivadent, Schaan, Lichtenstein), and nanofiller composite resin teeth (Veracia, Shofu Inc., Kyoto, Japan) with different brands were used, for a total of four different denture teeth groups. Denture teeth were subjected to four beverages (tea, filtered coffee, cola, and cherry juice) and distilled water as control. The test period of 24 hours appears comparable to approximately 1 month of normal beverage consumption. The test periods used in this study were arranged according to this protocol and 1 week, 1 month, 3 months, and 6 months of normal beverage consumptions were simulated. From each group, 10 maxillary first central denture teeth were immersed in each of the five solutions. The baseline, 1st week, 1st month, 3rd month and 6th month values for colour change of denture teeth were measured. The differences of each value were calculated by one-way ANOVA and Tukey HSD test statistically (α=0.05).
Results: For colour changes (δE) there was no significant difference among the specimens immersed in distilled water ($p>0.01$). The highest colour changes were recorded for the specimens of Integral and Major immersed in cola, whereas for the specimens of Veracia and Orthosit immersed in tea ($p<0.01$).
Conclusions: Within the limitations of this study, daily intake of common beverages may lead to colour changes of denture teeth. Microfiller composite resin denture tooth material is recommended due to its improved physical properties.

Key words: beverages; colour stability; denture tooth; nano-composite

Introduction

Denture teeth are important components of removable dentures for function and fonation. The preservation of the created occlusion, chewing effectiveness, and esthetic requirements are the most wanted features for denture teeth. Colour stability, smooth surface and wear resistance are supposed for the denture tooth materials. [1] Acrylic resin and porcelain are the most used materials. However, none of them fully meet the requirements for an ideal denture tooth. [2] Recently, composites attract attention as denture tooth material. Composite resin denture teeth available in the market are differed in terms of many properties. These properties are filler shape, filler amount, polymer type, and cross linking. [2] Composite denture teeth with nano fillers have also been fabricated with the effect of nanotechnology in dentistry. [3,4] Some studies showed that nanocomposite denture teeth are more durable than acrylic resin teeth and microfiller composite resin teeth. [3,5]

One of the important factors to achieve aesthetics in removable dentures is the colour stability of the denture tooth material and this is an important criterion in tooth selection. [1] The colouring of resin-based materials can be caused by internal and external factors. The colour stability of denture teeth depends not only on their chemical and physical properties, but also on the nutritional habits of the patients. Chemicals in beverage formulations can cause corrosion and surface degradation, resulting in unaesthetic surface discoloration. Apart from these, the effects of beverages may vary

depending on the amount and frequency of intake. [6] The liquid remains in the mouth for only a few seconds before swallowing occurs. The amount of liquid remaining in the mouth after swallowing is less than 1 mL. This limits the amount of beverage that encounters teeth and restorations. There is not enough information about the clinical performance of these denture tooth materials. So, studies are needed to compare the structural properties of denture teeth in relation to discoloration. In this study, it was aimed to compare the physical properties of denture teeth produced by four different manufacturers, with structural differences, by evaluating their colour stability when exposed to frequently consumed beverages for different time periods. The hypothesis of this study is that the structural difference of denture teeth affects their resistance to coloration.

Methods

Maxillary cenral incisors of conventional acrylic resin (Major Dent, Major Prodotti Dentari S.p.A., Moncalieri, Italy), reinforced acrylic resin (Integral, Merz Dental GmbH, Lütjenburg, Germany), microfiller composite resin (SR Orthosit PE, Ivoclar Vivadent, Schaan, Lichtenstein), and nanofiller composite resin teeth (Veracia, Shofu Inc., Kyoto, Japan) were used, for a total of 4 different denture teeth groups (shade A2).

For each liquid medium (tea, filter coffee, cola, cherry juice, distilled water), 10 samples from each tooth group were randomly selected. A total of 200 upper central teeth were used. Cylindrical molds with a thickness of 0.5 cm and a diameter of 2 cm, suitable for each tooth brand, in which the labial surfaces of denture teeth are up and placed parallel to the ground, were prepared from A2 colour autopolymerizing acrylic (Dent Temp Set A2, GDF GmbH, Germany). A nest was created for these molds in the polyacetate mold where the colorimeter device can sit. In this way, acrylic molds could be placed in the slot in a single position and standardization was ensured in every measurement. All samples were kept in an oven (Köttermann GmbH & Co., Labortechnik, Uetze, Germany) in distilled water for 24 hours at 37°C in a dark environment before testing. Initial measurements were made before the samples were immersed in the solutions. For the liquid environments where the samples will be kept, the beverages to be tested were prepared according to certain rules and 5 ml liquid for each sample. The solutions were reconstituted daily during the testing period. All samples were kept in a dark environment (oven) at 37°C to mimic the oral environment.

For our study, in which we aimed to evaluate the colour changes of 6 months usage of the prostheses, we determined a holding period in a liquid to simulate this 6-month period, considering the material we used. Although there is no definitive protocol on this subject in previous studies, von Fraunhofer and Rogers [7], in their study investigating the amount of enamel dissolution, accepted a 14-day soaking period as equivalent to 13 years of fluid intake as a result of tooth-beverage contact.7 In the study of Güler et al. [8] for composite resin materials used in temporary restorations, it was stated that a 24-hour storage period in liquid simulates a 1-month fluid intake. In our study, using this protocol, we determined the immertion times of the samples (5.6 hours, 24 hours, 3 days, 6 days) and the time periods they simulated (1 week, 1 month, 3 months, 6 months). Except for the initial measurements, measurements were made after each test period. Test solutions were refreshed at most every 24 hours during the test periods. At the end of the immersion period, the samples taken from the solutions were washed under tap water before each measurement, dried with a towel, and measurements were made. All colour measurements were carried out in a colour measurement box, which was completely covered with a neutral gray background cardboard, containing a fluorescent lamp (Activa 172 Sylvania, Germany) that could imitate 95% of daylight on the upper side. In the upper central teeth used for colour measurements, measurements could be made from the same region corresponding to the middle third of their labial faces after each test period. The CIELAB Colour System was used to evaluate the coloration that occurs because of immersion in liquids. When determining the δE value, the colour parameter difference was calculated with the formula of δE= [(δL*)2+(δa*)2+(δb*)2]½ over the colour range L*a*b*. In other words, the colour differences of the samples at the beginning of the 1st week, 1st month, 3rd month, and 6th month, respectively, were evaluated.

At the end of the study, the analysis of all the data obtained from the measurements and the calculated values were analyzed by the IBM SPSS Statistics 19 statistical analysis program. The differences of each value were calculated by one-way ANOVA and Tukey HSD test statistically (p<0.01).

Table 1. The change of colour difference (δ*E*) values of samples in different beverages with time.

	Baseline 1st Week	Baseline 1st Month	Baseline 3rd Month	Baseline 6th Month	p
Distilled water	0,59±0,57	0,67±0,51	0,69±0,45	0,61±0,40	0,754
Tea	1,42±0,82a	0,98±0,75b	0,97±0,50b	1,48±0,68a	0,000**
Filtered coffee	0,81±0,60a	0,96±0,44a	0,94±0,53a	1,45±1,11b	0,001**
Cola	1,04±1,03	1,17±1,18	1,28±1,71	1,77±2,04	0,171
Cherry juice	0,68±0,71a	1,21±0,77ab	0,86±0,53a	1,50±1,43b	0,001**

**p<0.01 (Statistically different.) For each analysis of variance, Tukey HSD results are indicated next to the mean±standard deviation results by lettering method. For each line; the same letters indicate that there is no difference between groups, and different letters indicate that the difference between groups is significant.

Table 2. The change of colour difference (δ*E*) values of different denture tooth samples with time.

	Baseline 1st Week	Baseline 1st Month	Baseline 3rd Month	Baseline 6th Month	p
Integral	1,00±0,93a	1,11±0,72a	1,24±1,25a	2,37±1,95b	0,000**
Major	0,91±0,83	1,13±1,09	1,17±1,06	1,33±1,02	0,227
Veracia	0,88±0,66a	0,74±0,31a	0,82±0,32a	1,14±0,53b	0,001**
Orthosit	0,86±0,83ab	1,00±0,79b	0,56±0,43a	0,60±0,43a	0,002**

**p<0.01 (Statistically different.) For each analysis of variance, Tukey HSD results are indicated next to the mean±standard deviation results by lettering method. For each line; the same letters indicate that there is no difference between groups, and different letters indicate that the difference between groups is significant.

Results

The interactions of beverage - time and denture tooth-time were evaluated (Table 1 and Table 2). The non-parametric Friedman Test was also used for the detection of individuals among the repetitive data.

For colour changes (δ*E*) there was no significant difference among the specimens immersed in distilled water (p>0.01). Tea and cherry juice had significant effects on colour changes from 1st month, whereas a significant difference was established for filtered coffee from 6th month (p<0.01). Significant colour changes were observed at 6th month for Integral and Veracia teeth and at 1st month for Orthosit teeth (p<0.01). The highest colour changes were recorded for the specimens of Integral and Major immersed in cola, and for the specimens of Veracia and Orthosit immersed in tea (p<0.01). All the δ*E* values were under the clinically acceptable level (δ*E*<3.5). In general, colour changes at 6 months were statistically higher for all denture teeth groups than at other times (Give p value). (p<0.01).

Discussion

We evaluated the discoloration of different denture teeth in this study. The null hypothesis of the study is approved.

The effect of beverages may be strong depending on the structural properties of denture teeth such as chemical composition or external properties such as finishing and polishing. Moreover, the effect of beverages on the properties of denture teeth may be directly related to the frequency and amount of intake.[6] The most staining was observed in the samples waiting in coke. This is followed by cherry juice, tea, coffee, and distilled water. The colour difference in the samples kept in distilled water was not significant. While coke has a lower pH than other liquids, it could increase the surface roughness of denture teeth. Nevertheless, rough surfaces retain surface staining mechanically more than smooth surfaces. In the study of Köksal and Dikbas[1], in which they compared the colour stability of porcelain and acrylic denture teeth in various liquids, coffee was found to be the most discoloring liquid in tea, coffee and cola.

The most important feature of nanocomposite denture teeth is that they have a homogeneous structure because this material is not very cross-linked but contains nano-sized inorganic fillers that are evenly dispersed without clumping in the matrix resin.[3] Different behavior of composite materials depends on the differences in the composition and filler distribution of the matrix. Factors affecting the properties of composites are monomer, filler, and bonding agents.[9] The filler content also affects the colour stability. An increased filler ratio reduces water absorption, which results in less surface deterioration. However, changes may occur because of continuous and natural decomposition of the material surface in the liquid medium. With the absorption of water, the filler and matrix connection are broken. This bond may also weaken in the presence of chemical solvents.[2] The increase in colour change in the 6th month of Veracia teeth may have occurred because of the weakening of the bond between the filler and the matrix.

Orthosit and Veracia composite resin teeth we used in our study have inorganic filler content of 42.9% and 5.9%, respectively.[3] In the study of Loyaga-Rendon et al.[3] in which they investigated the structural properties of denture teeth, it was observed that the filling distribution of Orthosit teeth was more homogeneous. Less filler amount of Veracia teeth may cause an increase in roughness values and lead to colour change.

In this study, we did not apply any abrasion and polishing process to denture teeth. By measuring from the buccal middle third regions of the samples, we used flat surfaces as much as possible. We ensured that the enamel layers retain their properties without abrading the denture tooth samples we used. According to the findings of a study conducted by Aysan et al.[10], it was observed that the samples kept in distilled water also showed staining over time. This result is surprising considering that distilled water is colorless. This situation was explained by the water absorption of the resin material kept in the liquid. It has been thought that changes may occur in the structure of the resin absorbing distilled water, which may lead to a change in the colour of the resin. We also kept the control group samples in distilled water in our study, but we did not observe any change in colour at the end of the test period.

Staining varied depending on the residence time of the samples in liquids.[7] Therefore, it is important to determine test times and measurement times in a way that reflects prosthesis use. We considered many studies when planning the testing period for our study.[1,6–8] It is thought that the 6-day test period we determined may reflect clinical conditions by simulating 6-month prosthesis use. The tooth surfaces encounter ingested food or drink for a very short time before being washed away by saliva.[11] This role of saliva was not considered in studies where samples were kept in solutions for a long time.[3,5,6] Therefore, while planning our study, we determined our test time by considering the possible contact time of the oral tissues and restorations before they are washed by saliva. The effects of saliva, such as its buffering capacity, pellicle formation, and contribution to remineralization, are difficult to mimic in vitro. These features are more important for studies on enamel.

It has been reported that in dentistry, colour changes begin to be noticed when $\delta E > 1.0$ and are acceptable up to $\delta E = 3.7$.[2] Considering the mean values in our study, the δE values of all groups did not exceed 3.7. except for Integral teeth. The colour difference values (δE) of all denture tooth samples did not exceed 2 until the end of the 6th month. While the δE values of Orthosit teeth never exceeded 1 in any time interval, the δE values of Veracia teeth increased above 1 only at 6 months. As a result, the colour difference values of all samples were below the acceptable value. According to the study of Paravina et. al.[12], the up-to-date thresholds are 1.2 for perceptible δE values and 2.7 for acceptable δE values.

Although Integral teeth contain crosslinks, the greater colour changes were attributed to the greater water absorption of the material as Loyaga-Rendon et. al. mentioned.[3] However, materials were not compared in terms of water absorption in our study. Structural changes in materials due to water absorption are also subjects that need to be studied. The fact that Orthosit and Veracia teeth are more resistant to colour change can be attributed to the increase in density depending on the presence and size of the filler, and thus less water absorption.[2]

Coloration occurs at the resin matrix, filler, and their interfaces. If the fillers are not coated with silane, voids form at the interfaces due to the filling of the resin matrix with water.[2] Composite resin denture teeth with nano-fillers coated with silane, which Imamura et al.[2] produced experimentally, showed the highest resistance to discoloration. The magnitude of the colour change is expressed as δE. In dental literature, many researchers have used δE values to evaluate the perceptibility of colour differences. We used CIE La*b* system to determine δE values. As a limitation of this study, although CIE La*b* system has the advantage of detecting small color changes, another system the CIEDE2000 formula is currently preferred for more sensitive calculation of color difference.

The effects of frequently consumed beverages on denture teeth should be supported by clinical studies as well as in vitro studies. The effects of the ingredients of the drinks should also be considered. Thus, material formulations can be developed to prolong the use of prostheses. The results of the study can be explained by the chemical compositions of the denture teeth used. In this direction, nanocomposite and microcomposite teeth may be promising options for denture tooth selection.

Conclusion

Within the limitations of this study, daily intake of common beverages may lead to colour changes of denture teeth. To improve this physical property, new denture teeth have been developed by controlling the filler particles and polymer matrix. Microfiller composite resin denture teeth may be recommended due to their resistance to discolouration.

Author Contributions

PÖ and ŞTD planned the study design. ŞTD prepared the samples and performed the laboratuary tests. PÖ evaluated the results. ŞTD wrote the text and PÖ made the necessary corrections.

Conflict of Interest

The authors declare that there are no conflicts of interest.

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