A Color Stability Comparison of Conventional and CAD/CAM Polymethyl Methacrylate Denture Base Materials

Usporedba stabilnosti boje konvencionalnih i CAD/CAM polimetilmetakrilatna za izradu baze Zubne proteze

Introduction

Polymethyl methacrylate (PMMA) resin has been successfully used for denture base materials for years (1,2). Several different kinds of denture base acrylic resins are used and named according to their production mode, such as auto-polymerizing resin, a urethane dimethacrylate resin and a CAD/CAM PMMA block resin stored in different storage media. Material and methods: 60 disc-shaped specimens (15×2 mm) were fabricated for each group. A total of 240 disc-shaped specimens were thermal-cycled for 5,000 cycles. Then specimens were randomized into 4 groups (n=15) according to storage media: coffee, coke, red wine and distilled water (control group). The color measurement of each sample was performed using a spectrophotometer before and after storage (after 7 and 30 days), and color changes (ΔE) were calculated. Results: All the denture base materials demonstrated dissimilar color changes after stored in the different storage media in both evaluation stages. In all storage media, CAD-CAM denture base resins showed the minimum in color change. In all denture base resins, red wine showed a higher degree of color change than coke or coffee. Conclusion: The color stability of CAD-CAM denture base resins is better than any of the other kind of denture base resins. The color change values of all groups except Eclypse stored in red wine had clinically detectable values.

Uvod

Polimetilmetakrilatna (PMMA) smola već se godinama uspješno primjenjuje kao materijal za izradu baze proteze (1,2). U potpunosti se sastoji iz različitih vrsta akrilatnih smola koje se dijele prema načinu polymerizacije, na primjer, autopolimeriziračka akrilatna smola, akrilatna smola polymerizirana toplinom, akrilatna smola polymerizirana svjetlosti, posebna smola polymerizirana u mikrovalnoj obredi i PMMA smola za računalno potpomognutu proizvodnju (CAD/CAM) koja dolazi u blokovima (3,4). Korištenje mađe troškove, jednostavnost rukovanja, odgovaračka mehanička i fizička svojstva i zadovoljavajuči izgled, tri materijali imaju mnoge prednosti. Unatoč tome, PMMA ima i nedostatke – preosjetljivost, promjenu boje, abraziju i poroznost (5,7).

Polimetylmetakrilatna smola (PMMA) je uspješno primjenjivana kao materijal za izradu baze proteze (1,2). Upotrebljava se nekoliko različitih vrsta akrilatnih smola koje se dijele prema načinu polymerizacije, na primjer, autopolimeriziračka akrilatna smola, akrilatna smola polymerizirana toplinom, akrilatna smola polymerizirana svjetlosti, posebna smola polymerizirana u mikrovalnoj obradi i PMMA smola za računalno potpomognutu proizvodnju (CAD/CAM) koja dolazi u blokovima (3,4). Korištenje mađe troškova, jednostavnost rukovanja, odgovarajuća mehanička i fizička svojstva i zadovoljavajuća izgled, tri materijali imaju mnoge prednosti. Unatoč tomu, PMMA ima i nedostatke – preosjetljivost, promjenu boje, abraziju i poroznost (5,7).
final denture. Eclipse denture base has showed significantly higher impact and flexural strength when compared to PMMA denture bases (8).

In recent years, with advancements in CAD/CAM technology, manufacturers have produced CAD/CAM PMMA based polymer blocks as an alternative for denture base resins (4,9). CAD/CAM PMMA block manufacturers claim that these materials will have better mechanical properties than conventional denture base resins (10). CAD/CAM PMMA based polymer blocks, that are polymerized under high temperature and high pressure conditions, reduce residual monomer release, improve optical properties, improve stability of color and facilitate the production of denture bases by easy milling (11, 12).

The appearance and color of denture base is an important property of the denture. In addition, denture base material should match the color and appearance of the underlying tissues (1). One of the most important clinical features of all dental materials is color stability and any color changes are indicators of aging or damaged materials (13-15). Additionally, the esthetic appearance of the prosthesis is one of the important factors in meeting the expectations of patients (16-18).

Various factors may affect the color change of denture base materials after prolonged use. These factors are: water absorption, stain accumulation, degradation of intrinsic pigments, dissolution of ingredients, foods, beverages and roughness of surface (1, 19, 20).

When assessing color alterations, visual examination is a subjective physiological and psychological procedure. On the contrary, when the spectrophotometer is used for a determination of color alteration, not only does it eliminate subjective interpretations but also allows identification of minor color alterations (21). A color system the name of which is The Commission Internationale de l’Eclairage (CIE) L*a*b is a constant color scale that includes all the colors visible to the human eye. Hence, it is appropriate for perceptual studies of color changes in dental materials (22).

Even though the current scientific data promote CAD/CAM-fabricated complete dentures clinical superiority, the data about their material properties are still limited (23). Therefore, the aim of the present study was to compare the influence of various storage media on the color changes of an autopolymerizing resin, heat polymerized resin, urethane dimethacrylate resin and a CAD/CAM PMMA block resin. The null hypothesis was that that different storage media does not affect the color changes in various denture base resins.

Materijali i metode

U ovom istraživanju upotrijebljene su četiri vrste smola za izradu baze proteze – autopolimerizirajuća smola (A), toplinski polimerizirajuća smola (H), svjetlosno polimerizirajuća smola (L) i CAD/CAM blok od smole (C). Svi materijali su izrađeni na bazi PMMA. Proizvođači savojevnu čvrstoću u usporedbi s bazama od PMMA-e (8).

Posljednjih godina, s napretkom u CAD/CAM tehnologije, proizvođači izrađuju polimerne blokove na bazi PMMA-e kao alternativu smolama za izradu baze proteze (4,9). Proizvođači CAD/CAM PMMA blokova tvrde da ti materijali imaju bolja mehanička svojstva od konvencionalnih smola (10). Blokovi PMMA-e za CAD/CAM obradu koji se polimeriziraju u uvjetima visoke temperature i tlaka, manje otpuštaju zaostatni monomer, imaju bolja optička svojstva, bolju stabilnost boje i omogućuju izradu baze proteze jednostavnim plasmanjem (11,12).

Izgled i boja baze važna su svojstva proteze. Uz to, baza proteze bojom i izgledom treba oponašati okolna tkiva (1). Jedna od najvažnijih kliničkih značajki svih stomatoloških materijala jest postojanje boje, pa su bila kakve promjene toga svojstva pokazateli starenja ili oštećenja materijala (13 - 15). Osim toga, estetski izgled proteze jedan je od važnih čimbenika u ispunjavanju očekivanja pacijenata (16 - 18).

Različiti čimbenici mogu utjecati na promjenu boje materijala za bazu proteze nakon duljeg korištenja. Među njima su upijanje vode, nakupljanje mljeva, degradacija intrinzičnih pigmenata, otapanje sastojaka, hrana, piće i hrapavost površine (1, 19, 20).

Pri procjeni promjene boje, vizualni pregled je subjektivni fiziološki i psihološki postupak. Ali kada se spektrofotometar rabi za određivanje promjene boje, taj uređaj ne samo da eliminira subjektivno tumačenje, nego omogućuje i prepoznavanje manjih promjena boje (21). Sustav boja koji je definirao Commission Internationale de l’Eclairage kao (CIE) L*a*b, konstantna je ljestvica boja koja uključuje sve nijanse vidljive ljudskom oku. Zato je prikladan za perspektivnu istraživanja promjene boje dentalnih materijala (22).

Iako aktualni znanstveni podatci govore u prilog kliničkoj nadmoci potpunih proteza izrađenih CAD/CAM tehnologijom, oni o svojstvima materijala još su ograničeni (23). Zato je svrha ovog istraživanja bila usporediti utjecaj različitih medija na promjene boje autopolimerizirajuće smole, toplinski polimerizirajuće smole, uretan-dimetakrilatne smole i CAD/CAM PMMA bloka. Nulta hipoteza glasi da različiti mediji za pohranu ne utječu na promjenu boje različitih smola za izradu baze proteze.

Material and Methods

Four kinds of denture base resins were used in this study; an auto-polymerizing resin (A), a heat polymerized resin (H), a light-activated resin (L) and a CAD/CAM block resin (C). All of the materials were used according to the manufacturer’s recommended procedures. The denture base resins used in this study and their manufacturers are summarized in Table 1.

Sixty disc-shaped specimens were prepared for each group. The CAD/CAM PMMA denture base materials were staje baza konačne proteze. Eclipse ima znatno veću udarnu i savojuvjeručtošću u usporedbi s bazama od PMMA-e (8).

Prilikom izrade proteza, kada se upotrebljava na bazi PMMA, dobivaju se bolja mehanička svojstva i stabilnost boje (8). U praksi, posebno u slučaju kliničkih istraživanja, koristi se više vrsta smola, a u ovom su koristi se autopolimerizirajuća, termopolimerizirajuća i CAD/CAM PMMA blok. Usporedba stabilnosti boje za izradu baze zubne proteze Dayan et al.

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designed as STL files and milled by CAD-CAM milling system (Ceramill Motion 2; Amann Girrbach). Then specimens were sliced with a cutting machine (IsoMet 1000; Buehler) and diamond-wafering blade ( IsoMet Blade 15 LC; Buehler) to obtain disc-shaped specimens 2 mm in thickness. Previously prepared CAD/CAM specimens were coated with high viscosity polyvinylsiloxane (Silagum Putty, DMG, Hamburg, Germany). Acrylic resins were mixed and applied in accordance to the manufacturers’ instructions. Heat polymerized acrylic specimens (Paladent 20) were polymerized at 74°C for 9 hours in the automatic polymerization unit (Kavo EWL 5501, Kavo Electrotechnisches Werk GmbH, Germany). Polymerizations of Weropress specimens were performed in a pressure pot heat cure unit ( Ivomat IP3, Ivoclar Vivadent AG, Schaan, Lichtenstein) at 45°C for 12 minutes under pressure of 2 bars.

A Teflon mold was designed with a transparent Plexiglas lid to produce the Eclipse specimens. The Eclipse specimens were cured in specific unit ( Enterra VLC Curing Unit; DeguDent GmbH, Hanau, Germany) using 15-minute polymerization cycle. The polymerization residue materials were then removed with tungsten carbide burs using a handpiece at low speed. Smoothing process was used with a 400-grit silicon carbide abrasive paper (English Abrasives) on a machine (Phoenix Beta; Buehler). The specimens were polished by a conventional pre-polishing technique using slurry of coarse pumice (IMIPOMZA; Imıcryl), water and a bristle brush on the rough pumice water slurry and a polishing lathe at a speed of 1500 rpm at 90 rpm and then fine polishing were done with using a polishing paste (chalk plus alcohol) and lathe flannel wheel for 90 seconds. All specimens were ultrasonically cleaned (Araysonic; Array) in distilled water for 10 minutes and dried with a paper towel.

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All operations were carried out at 23°C to ensure standardization by the same operator and to avoid changes due to temperature. In accordance with the recommendations of the coffee manufacturer, a coffee solution was prepared by mixing 15 g of instant coffee powder (Nescafé Classic; Nestlé, Vevey, Switzerland; pH 5.56) with 200 mL of hot water and sugar free. After the preparation, the coffee solution was allowed to cool down to room temperature. There was no special preparation for the coke (Coca Cola Co, Atlanta, GA; pH 2.37) or red wine (Vinkara Winehouse, Ankara, Turkey; pH 3.6) groups. The specimens were kept in storage media for 15 minutes twice per day, the solution media were refreshed on a daily basis for up to 30 days. The pH values of the storage media were verified by a pH meter (HI 221; Hanna Instruments Inc., Woonsocket, RI) before each storage. After the storage periods had been completed, the specimens were washed with and then stored in distillled water. This procedure was followed for 30 days. The specimens were kept in distilled water at 37°C between storage periods.

The color data was recorded before and after storage (7 and 30 days) in different media according to the CIE L*a*b* color scale using a spectrophotometer (Data color CHECK 3, USA). The color difference (ΔE) between the color coordinates was calculated by applying the formula \( \Delta E^* = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2} \) in order to compare values before and after the storage treatment. Each sample was subjected to color measurement four times and the average value was recorded.

**Statistical Analyses**

Statistical analysis was performed using Statistical Package for Social Sciences (SPSS) for Windows software (IBM Corp. Released 2013. The IBM SPSS Statistics for Windows, Version 22.0, Armonk, NY, USA). The Shapiro–Wilks test was used to identify if the measured parameters met the assumptions of normal distribution. The results showed that the data were not normally distributed. Between the groups, the color differences (ΔE) were analyzed by the Kruskal–Wallis test at 7-day and 30-day periods, while median and range values were used in the descriptive statistical analysis. Between the groups, multiple comparisons were performed using the Mann-Whitney U test.

**Results**

Table 2 shows the color change values after storage in the four different storage media for four denture base materials after the period of 7 and 30 days. The Weropress denture base resins demonstrated the highest color change in red wine, which represents a significant difference when compared to the other storage media both at 7 and 30 days (p<0.001). The Paladent denture base resins demonstrated the highest color change in distilled water, which represents a significant difference when compared to the other storage media after 7 days, after 30 days it demonstrated the highest color change in red wine, which represents a significant difference when compared to the other storage media (p<0.001). The Eclypse dent-
Color Stability of Denture Base Materials

Table 2. Different denture base resins after immersion in different solutions at 1 week and 1 month.

| Material • Materijal | Solutions • Otopina | 1 Week • 1 tjedan | 1 Month • 1 mjesec |
|----------------------|----------------------|-------------------|-------------------|
|                      |                      | Mean Rank • Srednji rankovi | Median (Range) • Medijan | Mann-Whitney U test • Mann-Whitneyev U-test | Mean Rank • Srednji rankovi | Median (Range) • Medijan | Mann-Whitney U test • Mann-Whitneyev U-test |
| Weropress            | a - Coffee • Kava    | 50.07 0.97 (0.22) | b,c > a 57.36 1.99 (0.16) | c > a,b |
|                      | b - Coke • Kola      | 66.07 0.99 (0.05) | 58.64 2.00 (0.14) |
|                      | c - Red Wine • Crno vino | 79.18 1.00 (0.08) | 95.50 2.45 (0.59) |
|                      | d - Distilled Water • Destilirana voda | 30.68 0.94 (0.74) | a > d 14.50 0.90 (0.82) |
|                      |                      |                   |                   |                   |
|                      |                      | 0.001             | 0.001             |
| Paladent             | a - Coffee • Kava    | 50.00 1.02 (0.06) | a,b > c 55.39 1.92 (0.19) |
|                      | b - Coke • Kola      | 53.04 1.02 (0.07) | 61.71 1.92 (0.44) |
|                      | c - Red Wine • Crno vino | 34.00 1.00 (0.08) | 94.39 2.17 (0.66) |
|                      | d - Distilled Water • Destilirana voda | 88.96 1.06 (0.24) | d-a,b 14.50 1.04 (0.14) |
|                      |                      |                   |                   |                   |
|                      |                      | 0.001             | 0.001             |
| Eclipse              | a - Coffee • Kava    | 90.36 1.08 (0.57) | a > b 62.94 3.02 (1.08) |
|                      | b - Coke • Kola      | 28.82 0.94 (0.15) | 43.46 2.90 (0.36) |
|                      | c - Red Wine • Crno vino | 73.86 1.04 (0.14) | c > b,d 98.50 3.59 (1.32) |
|                      | d - Distilled Water • Destilirana voda | 32.96 0.96 (0.15) | 14.50 1.18 (0.96) |
|                      |                      |                   |                   |                   |
|                      |                      | 0.001             | 0.001             |
| Cad-Cam Acrylic      | a - Coffee • Kava    | 71.14 0.76 (0.16) | a > b 68.61 1.08 (0.27) |
|                      | b - Coke • Kola      | 40.93 0.53 (0.13) | 44.39 0.99 (0.29) |
|                      | c - Red Wine • Crno vino | 97.86 0.90 (0.50) | c > a 98.50 2.04 (1.03) |
|                      | d - Distilled Water • Destilirana voda | 16.07 0.44 (0.19) | 14.50 0.43 (0.64) |
|                      |                      |                   |                   |                   |
|                      |                      | 0.001             | 0.001             |

The color stability of denture base resins demonstrated the highest color change in coffee, which represents a significant difference when compared to the other storage media after 7 days, after 30 days it showed the highest color change in red wine, which represents a significant difference when compared to the other storage media (p<0.001). The CAD-CAM acrylic denture base resins demonstrated the highest color change in red wine, which represents a significant difference when compared to the other storage media at both 7 and 30 days (p<0.001).

Table 3 shows the discoloration effects of storage media on the denture base resins after 7 and 30 days. The coffee solution, 7 and 30 days, affected the Eclipse denture base the most (p<0.001). The coke solution affected the Paladent denture base the most after 7 days, at the end of 30 days the Eclipse denture base was the most affected (p<0.001). The red wine solution affected the Eclipse denture base the most both at 7 and 30 days (p<0.001). The distilled water affected the Paladent denture base the most 7 days, at the end of 30 days the Eclipse denture base was the most affected (p<0.001).
Discussion

In the current study, the previously introduced CAD/CAM PMMA block resins were compared with an auto-polymerizing resin, a conventional heat polymerized resin, a urethane dimethacrylate resin, as storage media using red wine, coke, and coffee because basically these beverages are frequently consumed by people. The denture base materials which were tested showed significantly different discoloration after storage in the different media at both evaluation stages. Hence, the null hypothesis of the study was rejected.

A color change that is more than detectable (ΔE>1.0) is considered acceptable up to a ΔE value of 3.3 in dentistry; above this value it is considered unacceptable (24,25). Only the Eclypse denture base groups, stored in red wine, showed that the discoloration was clinically unacceptable after the 30 days (ΔE 3.59).

The color change was determined for all the acrylic denture base resins and they all increased over time. There are intrinsic and extrinsic factors that can cause discoloration of denture base materials (15,26). These factors include: physical chemical change, stain accumulation, the residual monomer used, water absorption and, degradation of intrinsic pigments, dissolution of the ingredients and the surface roughness. It is well known that beverages such as coffee, 

Rasprava

U ovom istraživanju CAD/CAM PMMA blokovi od smole uspoređeni su s autopomerizirajućom smolom, konvencionalnom toplinsko polimerizirajućom smolom i uretan-dimetakrilatnom smolom u crnom vinu, koli i kavi kao medijima za pohranu, jer su to često konzumirani napitci. Testirani materijali za izradu baze proteze pokazali su značajno različitu diskoloraciju nakon pohranjivanja u različitim medijima u objema fazama ocjenjivanja. Zato je nulta hipoteza istraživanja odbačena.

U dentalnoj medicini vidljiva promjena boje (ΔE > 1) smatra se prihvatljivom do vrijednosti od ΔE = 3,3; razlika iznad toga je neprihvatljiva (24, 25). Samo skupina materijala Eclypse pohranjena u crnom vinu pokazala je klinički neprihvatljivu promjenu boje nakon 30 dana (ΔE 3,59).

Utvrđena je promjena boje svih akrilata za proteze i sve su se s vremenom povećavale. Postoje unutarnji i vanjski čimbenici koji mogu uzrokovati promjenu boje materijala za izradu baze proteze (15, 26). To su fiziološko-keemijske promjene, nakupljanje mrlja, zaostatni monomer, upijanje vode i razgradnja unutarnjih pigmenata, otapanje sastojaka i hrapavost površine. Poznato je da napitci poput kave i koli te crno vinu uzrokuju promjenu boje svih smola za izradu baze proteze (18, 22, 26).
coke and red wine enhance the discoloration of all denture base resins (18, 22, 26).

Zuo et al. examined the discoloration of different denture base resins after immersion in different cleaners and different beverages (26). The conclusion of the study points to the fact that color change of the Eclipse denture base resin was much higher than the clinically acceptable value of ΔE 3.3. This is in line with the present study results which showed that the Eclipse denture base groups had the most defined color change. This result could be due to the tendency of high water absorption in light-activated denture base materials when compared to the other materials. Kerby et al. reported that Eclipse is also sensitive to hygroscopic expansion; this is caused by the 2 hydrophilic urethane groups within its molecular structure, but less than PMMA (27). Further studies, which take both water absorption and color change of different denture base materials into account, are needed.

CAD/CAM fabricated acrylic has achieved a better color stability, better mechanical properties, prevention of porosities and a better fit than the conventional PMMA resins. Polymerization methods and composition of a resin matrix may have a great effect on its stability of color (28-30). Conventionally fabricated PMMA resins are dependent on the technician, mixing proportions of the resin components, polymerization device and duration of the polymerization, among others (31). According to the results of the present study, the least color change was observed in CAD-CAM denture base resins in all of the beverages. This is due to the fact that it can be better polished, there is no porous structure, less water absorption and less wear as proved in the literature.

Alp et al. examined the effect of coffee solutions on the discoloration of different CAD-CAM acrylic resins, likewise the current study, researchers reported that clinically admissible color changes did not occur in different denture base acrylic resins due to coffee staining (32). However, researchers observed that the color change and surface roughness in heat-polymerized and different pre-polymerized CAD-CAM PMMA specimens were not significantly different. This may be attributed to the 8 hours of heat polymerization of the heat-polymerized control group, which enhance its physical features.

Presently, there are varieties of options available including the new generation of PMMA-based self-polymerizing denture base materials. These materials have a shorter production process but the residual monomer can cause an enhance risk of tissue reactions and it has decreased mechanical properties (33). According to a previous study, Weropress have acceptable flexural properties when compared to traditional heat polymerized resins and light-activated resins (34). The present study reported that Weropress had a clinically acceptable color change and this material needs further study in order to determine residual monomer degree and cytotoxicity.

In the previous study, similar to other studies, a minimum color change was detected in the specimens which were immersed in distilled water (1, 35). The reason for this situation is that there are no substances which may cause discoloration in materials, and pH of the distilled water does not cause roughness on the surface due to neutrality.

Zuo and suradnici ispitali su promjenu boje različitih smola za izradu baze proteze nakon uranjanja u različita sredstva za čišćenje i različita pića (26). Zaključak istraživanja pokazao je da je promjena boje smole Eclipsea znatno veća od klinički prihvatljivije vrijednosti ΔE 3,3. To je u skladu s rezultatima ovog istraživanja koji su pokazali da je Eclipse najviše promijenio boju. Taj rezultat može biti posljedica sklonosti prema apsorpciji vode materijala za bazu proteze koji se svjetlosno polimeriziraju u usporedbi s drugim materijalima. Kerby and suradnici izvesti su da je Eclipse također osjetljiv na higroskopno širenje; to je uzrokovano dvjema hidrofilnim uretanskim skupinama unutar njegove molekularne strukture, ali manje od PMMA-e (27). Potrebna su daljnja istraživanja koja će uzeti u obzir i apsorpciju vode i promjenu boje različitih materijala za izradu baze proteze.

Akrilati obrađeni CAD/CAM tehnologijom postižu bolju stabilnost boje i bolja mehanička svojstva, manje su po- rozni i imaju bolji dosjed u odnosu prema konvencionalnim PMMA smolama. Metode polimerizacije i sastav smolaste matrice mogu znatno utjecati na stabilnost boje (28 - 30). Konvencionalno proizvedene PMMA smole, između ostaloga, ovise o tehničaru, omjeru miješanja komponenti smole, polimerizacijskom uređaju i trajanju polimerizacije (31). Prema rezultatima ovog istraživanja, najmanja promjena boje nakon pohranjivanja u svim napitcima, zabilježena je za CAD/CAM materijal za izradu baze proteze. To je zato što se može bolje polirati, nema poroznu strukturu, manje upija vodu i manje se troši, kao što je dokazano u literaturi.

Alp i suradnici ispitali su utjecaj kave na diskoloraciju različitih CAD/CAM akritalnih smola i, kao i u ovom istraživanju, izvijestili da se klinički prihvatljive promjene boje nisu pojavile na različitim akritalnim smolama za izradu baze proteze nakon uranjanja u kavu (32). No uočili su da se promjena boje i hrapavost površine toplinski polimerizirajućih i različitih pretpolimeriziranih CAD/CAM PMMA uzoraka nisu značajno razlikovale. To se može pripisati osmatranjima toplinskog polimeriziranja uzoraka kontrolne skupine, što poboljšava njihova fizička svojstva.

Trenutačno postoje razne mogućnosti, uključujući novu generaciju autopolimerizirajućih materijala za izradu proteza na bazi PMMA-e. Ti materijali imaju kraći proizvodni proces, ali rezidualni monomer uzrokuje povećan rizik od reakcija tkiva i lošija su im mehanička svojstva (33). Prema ranije provedenom istraživanju, Weropress ima prihvatljiva svojstva savijanja u usporedbi s tradicionalnim toplinski i svjetlosno polimerizirajućim smolama (34). To istraživanje pokazalo je da Weropress klinički prihvatljivo mijenja boju i da je za taj materijal potrebno dodatno analizirati stupanj rezidualnog monomera i citotoksičnosti.

U jednoj ranijoj studiji, slično drugim istraživanjima, minimalna promjena boje otkrivena je u uzorcima koji su urojneni u destiliranu vodu (1, 35). Razlog za to jest što u njoj ne postoje tvari koje mogu uzrokovati promjenu boje na materijalu, a pH destilirane vode ne uzrokuje hrapavost površine zbog neutralnosti.

Dokazano je da sadržaj alkohola u napitcima uzrokuje degradaciju površine i ekspanziju, a time i lošija fizička svojstva smole. Učinak bojenja crvenog vina može biti uzrokovani
Coloring effects of red wine can be caused by its alcohol content that causes denture base surfaces to become rough (35). In the current study, a higher color difference for all denture base resins was observed in the red wine group than the coke or coffee group. Although red wine has a relatively low acidic pH (3.6) when compared to coke, it still caused greater discoloration.

Other explanations of the coloring effects of red wine may be the softening of the materials from the absorption of alcohol molecules into the organic matrix and following change in surface smoothness (36-38). The most probable cause is that the acidic pH and alcohol content of red wine affected the surface roughness of the prosthetic base. Red wine contains anthocyanin that is a water-soluble pigment which provides the grapes their color (39,40). The color change of the resin denture base which was stored in red wine was presumably a result of the concentration of the red color coming from its pigments, along with the higher absorption of the red pigments due to alcohol, which has a plasticizing effect on the organic matrix during the storage period, thus causing a significant color change in the denture base.

The present study has a number of limitations. First, the present in vitro result prerequisites need to be tested in vivo trials. However, in vivo studies are more challenging to be carried out. Besides, standardization in vivo studies is less likely to be accomplished using the methods applied in the current study. Although, the discoloration of denture base materials evaluated in vitro methods may not be as accurate or valid as those obtained through in vivo methods, they can provide useful guidance for clinical applications. Despite the limitations of the current study it presents beneficial evidence regarding the color change of recently introduced CAD-CAM denture base resins and the discoloration of some beverages, which are frequently used up in daily life.

Conclusion

Within the limitations of this in vitro study, the following conclusions could be drawn: The color stability of CAD-CAM denture base resins is better than that of some other kinds of denture base resins. All the changes in the color values of the groups, except those in Eclipse which was stored in red wine, were under the clinically perceptible value. The color stability of the Eclipse denture base resin was lower compared to other denture base groups. All beverages used in the study had an effect on color change.

Conflict of interest

The authors report no conflict of interest.

Zaklučak

Uzimajući u obzir ograničenja ovog istraživanja in vitro, može se zaključiti sljedeće: stabilnost boje CAD/CAM materijala za izradu baze proteze bila je bolja od ostalih smola; sve promjene boje u skupinama, osim za Eclipse koji je pothranjen u crvenom vinu, bile su klinički vidljive; stabilnost boje materijala Eclipse bila je niža od ostalih skupina materijala za bazu proteze; sva pića korištena u istraživanju utjecala su na promjenu boje.

Sukob interesa

Autori nisu bili u sukobu interesa.
Sapotak
Cilj: Željela se procijeniti stabilnost boje toplinsko polimerizirajuće smole, autopolimerizirajuće smole, waste-based dentures, acrylic block of polymethylmethacrylate (PMMA) embalzirani u zličitim medijima. Materiaj i metode: Za svaku skupinu proizvedeno je 60 uzorka u obliku pločica (15 × 2 mm). Ukupno 240 uzoraka termooxidiran je u 7500 čikusa. Izum se uzorci slučajnim odbiri- rom podijeljeni u četiri skupine (n = 15) prema mediju za pohranu: kava, kola, crno vino i destilirana voda (kontrolna skupina). Mjerenje boje svakog uzorka obavljeno je spektrofotometriju prije pohranjivanja i poslije toga postupka (nakon 7 i 30 dana) te su izračunate razlike u boji (CE). Rezultati: U svim materialima za bazu proteze dogodile su se promjene boje različita stupnja nakon pohranjivanja u različitim medijima tijekom obaju mjerenja. U svim medijima za pohranjivanje CAD/CAM materijali minimalno su promijenili boju. U svim materijalima za izradu baze proteze crno vino uzrokovalo je veći stupanj promjene boje od kola i kave. Zaključak: Stabilnost boje CAD/CAM materijala za izradu baze proteze bila je bolja od bilo koje druge vrste materijala. Vrijednosti promjene boje u svim skupinama pohranjenih u crnom vinu bile su klinički vidljive (osim Eclipsa).

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