NAUČNI RAD
SCIENTIFIC ARTICLE

UTICAJ POLIRANJA NA PROMENU BOJE I SJAJNOSTI KOMPOZITA

POLISHING-DEPENDENT CHANGES IN COLOR AND GLOSS OF COMPOSITES

[1]LeeAnn Walker, [2]Rade D. Paravina, [3]John M. Powers

[1]PRIVATE PRACTICE BAYTOWN, [2]FACULTY ASSOCIATE, DEPARTMENT OF RESTORATIVE DENTISTRY AND BIOMATERIALS SCIENTIST, HOUSTON BIOMATERIALS RESEARCH CENTER, THE UNIVERSITY OF TEXAS DENTAL BRANCH AT HOUSTON
[3]DEPARTMENT OF RESTORATIVE DENTISTRY AND BIOMATERIALS, DIRECTOR, HOUSTON BIOMATERIALS RESEARCH CENTER, THE UNIVERSITY OF TEXAS DENTAL BRANCH AT HOUSTON, U.S.A.

Kratak sadržaj

Cilj rada: Analizirani su boja i sjajnost četiri različita kompozita nakon primene različitih metoda finiranja i poliranja.
Metod: Dvadeset uzoraka (dijametar 10 mm, debljina 3 mm) je napravljeno od svakog od sledeća četiri kompozita: microfill (A110), microhybrid (Z250), packable (P60), and nanofill (EXM 612). Svi kompoziti su bili iste boje (A3). Po pet uzoraka od svakog kompozita je imalo sledeći tretman: I) bez ikakvih intervencija/kontrolna grupa (MC); II) poliranje gumicom i sitno granuliranom pastom za poliranje (PCP); III) nahrapavljeno karbidnim borerom, a zatim polirano Soflex diskovima (BS); ili IV) nahrapavljeno i polirano (kao pod III), a zatim polirano gumicom i pastom (BSP). Boja i sjajnost svakog od uzoraka su zatim mereni kolorimetrom i "small-area" glossmetrom. L, a* i b* koordinate su beležene i izračunavane su ΔE^*_{ab} vrednosti. $\Delta E^*_{ab} \geq 3.7$ je smatrano lošom usklađenošću boja. Sjajnost je beležena u jedinicama za sjajnost (GU, gloss units). Podaci su analizirani pomoću analize varijanse i Fisherovog PLSD testa sa nivoom značajnosti od 0.05.*
Rezultati: Najveća razlika u boji između testiranih kompozita je zabeležena između microfilla i nanofilla, ΔE^*_{ab} = 10.4 (0.1) u MC grupi. Najniža razlika zabeležena je između Z250 i P60 u BS grupi, ΔE^*_{ab} = 2.1 (0.3). Što se tiče različitih tehnika poliranja, 13 od 24 ΔE^*_{ab} vrednosti bilo je ≥ 1.0. Najviša razlika u boji iznosila je 2.9 (0.3) i zabeležena je između MC/P60 i BSP/P60. Najniža ΔE^*_{ab} bila je 0.4 (0.2), između A110/PCP i A110 kod BS. Razlike u sjajnosti između kompozita i između tretmana bile su statistički značajne (p < 0.0001, Power 1.00), pri čemu je najveća sjajnost zabeležena za A110 pri MC tretmanu, a najniža za EXM 612 pri BSP.
Zaključci: Razlike u boji između različitih metoda poliranja bile su male i praktično klinički neprimetne. Razlike u boji između kompozita bile su uočljive i u mnogim slučajevima više od vrednosti koja označava lošu usklađenost boja. Površine kompozita polimerizovane kroz providnu matricu imale su najveću sjajnost, bez obzira na tip kompozita. Najveća sjajnost nakon poliranja zabeležena je za mikrofilni kompozit. Niske vrednosti sjajnosti zabeležene su za nanofil nakon PCP i BSP tretmana, a za mikrohibrid nakon BS i BSP tretmana.

Ključne reči: *kompozit, poliranje, boja, sjajnost, kolorimetar*

Abstract

Purpose: The color and gloss of four different resin composites were evaluated following various steps in finishing and polishing.
Methods: Twenty specimens (10-mm diameter, 3-mm thick) were made from each of four composites: microfill (A110), microhybrid (Z250), packable (P60), and nanofill (EXM 612), all of the same shade (A3). Five specimens of each composite were either: I) untouched/control (MC); II) polished with a rubber prophy cup and fine grit polishing paste (PCP); III) roughened with a carbide bur, then smoothed with Soflex discs (BS); or IV) roughened and smoothed (as in III), then polished with prophy cup and paste (BSP). Color and gloss of each specimen was then measured using a colorimeter and a small-area glossmeter, respectively. L, a*, and b* coordinates were recorded and ΔE^*_{ab} values were calculated. A $\Delta E^*_{ab} \geq 3.7$ was considered to be a poor match. Gloss was measured in gloss units (GU). Data were analyzed by analysis of variance and Fisher's PLSD at the 0.05 level of significance.*
Results: The color difference among the composites tested was greatest between the microfill and the nanofill composite, ΔE^*_{ab} = 10.4 (0.1) in the MC group. The lowest recorded ΔE^*_{ab} was 2.1 (0.3), for comparison between Z250 and P60 of the BS group. When polishing techniques were compared, 13 of the 24 ΔE^*_{ab} values calculated were ≥ 1.0. The highest recorded color difference was 2.9 (0.3), between MC/P60 and BSP/P60. The lowest value of ΔE^*_{ab} was 0.4 (0.2) between A110/PCP and A110/BS. Gloss differences were significant both among composites and among treatments (p < 0.0001, power 1.00), with A110/MC having the highest gloss values and the EXM 612/BSP having the lowest.
Conclusions: The color differences among polishing methods were small and unlikely to be detectable clinically. The color differences among composites were detectable and, in many cases, above the value that indicated a poor match. A composite surface cured against Mylar had the highest gloss value, regardless of the composite type. The highest gloss values after polishing were recorded for the microfill. Low gloss values were obtained for the nanofill after prophylaxis-type polishing and for the microhybrid after treatments with both bur and Sof-lex discs as well as bur and Sof-lex discs followed by prophylaxis.

Key words*: resin, polish, color, gloss, colorimeter*

Uvod

Lep osmeh je podjednako važan i za odrasle i za decu. U stvari, deca uzrasta od 3 godine su sposobna da naprave razliku između onih vršnjaka čiji je izgled privlačan i onih za koje se to ne bi moglo reći.[1,2] "Neprimetna" restauracija je krajnji cilj estetske stomatologije, bez obzira na uzrast pacijenta.[3]

Uskladiti boju zuba i kompozita, međutim, još uvek predstavlja težak zadatak, uprkos postojećoj širokoj paleti kompozita i nijansi. Razlike u boji su zabeležene kod ključeva za određivanje boje zuba istih proizvođača, kao i između nominalno istih nijansi kompozita i ključeva za određivanje boje zuba različitih proizvođača.[4,5] Štaviše, faktori kao što su razlike između serija, promene boje izazvane polimerizacijom i starenjem materijala, različita translucentnost i efekat dvoslojne strukture mogu dalje komplikovati usklađenost boja i vek restauracije. Razlike u boji su takođe povezane sa poliranjem zubnog materijala.[6,7] Sa toliko mnogo faktora koji utiču na rezultat, nije iznenađujuće da određivanje boje ostaje svakodnevna briga i sada kada su estetske restauracije rutinski deo dentalne prakse.

Po aplikovanju restauracije, margine kompozita se moraju adaptirati tako da stvore jedinstvenu, biokompatibilnu površinu koja smanjuje retenciju bakterijskih naslaga. Ma koliko bilo idealno, ovo prilagođavanje neće dovesti do alterisanja površinskog integriteta ili izgleda restauracije koja je urađena sa toliko pažnje.

Kolorimetrijski sistemi koriste brojeve koji su u skladu sa utiskom posmatrača o datoj boji, dok uređaji za merenje boje omogućavaju standardizovane izvore svetlosti i optičku geometriju. Iako postoji nekoliko kolorimerijskih sistema, u ovoj studiji je korišćen CIE L *a*b sistem, sa sledećim kolor koordinatama:

- L* je oznaka za svetlinu objekta i kreće se u rasponu od 0 (crno) do 100 (belo)
- a* je oznaka za zeleno (-a*) – crvenu (+a*) koordinatu
- b* je oznaka za plavo (-b*) – žutu (+b*) koordinatu.

Uopšte uzev, smatra se da 50% posmatrača pod kontrolisanim uslovima može uočiti razliku u boji od $\Delta E^*_{ab} = 1$.[8] Razlika od $\Delta E^*_{ab} \leq 2$ se

Introduction

An esthetically pleasing smile is important to adults and children alike. In fact, children as young as three years of age were able to distinguish between attractive and unattractive peers.[1,2] Indeed, an unrecognizable restoration seems to be the ultimate goal of esthetic dentistry, regardless of patients' age.[3]

The task of matching the tooth shade with the composite's shade, however, remains difficult, even with such a wide variety of composite types and shades from which to choose. Color differences were recorded between the same manufacturer's shade guides as well as among nominally the same composite shades and shade guides of different manufacturers.[4,5] In addition, factors such as variation between batches, curing-dependent color changes, aging-dependent color changes, varying translucency and double-layer effects can further complicate the shade-matching and longevity of restoration. Color differences are also associated with the polishing of dental materials.[6,7] With so many variables, it is not surprising that shade matching remains a daily concern when esthetic restorations are a routine part of dental practice.

Once a restoration is placed, composite margins must be manipulated to create a uniform, biocompatible surface that minimizes plaque retention. Ideally, this manipulation will not compromise the surface integrity or appearance of the restoration that was so painstakingly placed.

Color notation systems use numbers that correlate with the observer's color impression, while color measuring devices enable standardized illuminants and optical geometries. Although several color notation systems exist, the CIE L*a*b* system was used in this study. CIE L*a*b* system color coordinates are as follows:

- L* is a measure of the lightness of an object and ranges from 0 (black) to 100 (white)
- a* is a measure of greenness (negative a*) or redness (positive a*)
- b* is a measure of blueness (negative b*) or yellowness (positive b*).

Color differences were greatest among composite types and considerably less among polishing methods. Generally, a $\Delta E^*_{ab} = 1$ is

smatra klinički prihvatljivom usklađenošću boja, možda manja odstupanja,[9] dok se razlika od $\Delta E^*_{ab} \geq 3.7$ smatra lošom usklađenošću boja.[10]

Površinska hrapavost odgovara sjajnosti površine kompozita. Što je površina glađa, sjajnost je veća. Kada se posmatra površinska hrapavost, teško je postići glatkoću i visoku sjajnost kao u slučaju kada se kompozit polimerizuje pomoću celuloidne trake.[11] Dok proizvođači kontinuirano razvijaju sve naprednije tehnike za poliranje, više puta se ispostavilo da aluminijum-oksid sistem za poliranje omogućuje najbolje rezultate. Konkretnije, u nedavno publikovanoj studiji Sof-Lex sistemom su produkovane glađe površine u odnosu na rezultate postignute pomoću Jiffy Composite gumicama, Enhance Composite Finishing & Polishing sistemom, Diacomp Intra-Oral Composite polirerima i Jiffy Composite Polishing četkicama.[12]

Ova studija je obavljena sa idejom da se izvrši upoređivanje boje i sjajnosti između različitih tipova kompozita i različitih metoda finiranja i poliranja. Nulte hipoteze su bile: I) nema razlike u boji između različitih tipova kompozita nominalno identičnih nijansi; II) nema razlike u boji između različitih metoda finiranja/poliranja primenjenim na iste ili drugačije kompozite; III) nema razlike u sjajnosti između kompozita nominalno identičnih nijansi; IV) nema razlike u sjajnosti između različitih metoda finiranja/poliranja primenjenih na iste ili različite kompozite.

Materijali i metode

Analizirano je četiri tipa kompozita (boja A3, tabela 1). Od svakog kompozita izrađeno je po 20 uzoraka oblika diska, prečnika 10mm i debljine 3mm. Kompoziti su nanošeni u politetrafluoretilenske cilindrične kalupe između okruglih celuloidnih matrica, a zatim pritiskani do debljine kalupa pomoću dve staklene pločice za mikroskop da bi se postigla glatka, uniformna površina. Svaki uzorak je potom polimerizovan u trajanju od 20 sekundi sa svake strane, prema uputstvima proizvođača. Za to je korišćena Epilar Trilight polimerizujuća lampa

considered to be detectable to 50 % of observers under controlled conditions.[8] A $\Delta E^*_{ab} \leq 2$ is found to be a clinically acceptable match, perhaps with some minor staining.[9] A $\Delta E^*_{ab} \geq 3.7$ is consi-dered to be a poor match.[10]

Surface roughness corresponds to the gloss of a composite surface. The smoother the surface, the higher the gloss. When considering surface roughness, it is difficult to reproduce the smoothness and high level of gloss achieved when composite is cured against a Mylar surface.[11] While manufacturers continually develop more advanced polishing techniques, an aluminum oxide polishing system has been shown repeatedly to produce the smoothest finished composite surface. Specifically, the Sof-Lex system produced a smoother surface than Jiffy Composite Polishing Cups, Enhance Composite Finishing & Polishing System, Diacomp Intra-Oral Composite Polishers and the Jiffy Composite Polishing Brushes in a recent study.[12]

This study was designed to evaluate color and gloss among different composites and finishing/polishing stages. The null hypotheses were as follows: I) there were no color differences among different composites of the same shade designation; II) there were no color differences among the different finishing/ polishing procedures performed on the same or different composites; III) there were no differences in gloss among composites of the same shade designation; and IV) there were no differences in gloss values among different finishing/ polishing procedures performed on the same or different composites.

Materials and Methods

Four composites (shade A3) were evaluated. (Table 1) Twenty disks of each composite, 10-mm in diameter and 3-mm thick, were fabricated. Composites were placed into polytetrafluoroethylene cylindrical molds between Mylar surfaces and pressed with glass microscope slides to achieve a smooth, uniform surface. Each specimen was then cured for 20 seconds on each side following the manu-

Tabela 1. Testirani kompoziti
Table 1. Composite Materials Tested

COMPOSITE	MANUFACTURER	TYPE	FILLER PARTICLE SIZE	LOT
A110	3M ESPE (St. Paul, MN)	Microfill	0.01-0.09μm (avg. 0.04μm)	2BN
Z250	3M ESPE	Micro-hybrid	0.01-3.5μm (avg. 0.6μm)	2UJ
P60	3M ESPE	Packable	0.01-3.5μm (avg. 0.6μm)	2MM
EXM-612 (Filtek Supreme)	3M ESPE	Nanofill	0.6-1.4μm clusters of 75 nm particles	RCX, RBX

(3M ESPE, St. Paul, MN) izlazne snage od 900 mW/cm^2. Uzorci su zatim ostavljani u inkubator na 37° C u toku 24 časa da bi se omogućila potpuna polimerizacija.[13] Pet uzoraka svakog tipa kompozita je nasumice raspoređeno u četiri grupe:

- Mylar/Kontrolna grupa (MC) – bez poliranja.
- Prophy Cup/Pasta (PCP) – polirano Nupro gumicom i Nupro "Extrene Bubble" polir pastom srednje granulacije (Dentsplz, Des Plains, IL) u toku 15 sekundi pri sporoj brzini i pritisku od 30 psi.
- Bur/Sof-lex diskovi (BS) i čitava površina uzoraka je najpre bila nahrapavljena dvanaestoperim bororom za finiranje (H48L-12, Brasseler USA, Savannah, GA), a potom ispolirana korišćenjem finih do ekstra finih Sof-lex diskova (3M ESPE, St Paul, MN) u trajanju od po 30 sekundi.
- Borer/Sof-lex disk/Prophy (BSP) – kao i kod BS grupe uz dodatno poliranje gumicom i pastom (kao kod PCP grupe) u trajanju od 15 sekundi.

Za kolorimetrijsku analizu korišćen je Minolta CR-321 fotoelektrični kolorimetar (Minolta Camera Co. Ltd., Osaka, Japan).[14] Aparat je bio podešen na sledeći način: izvor svetlosti D65, 2° standardni posmatrač, 45° cirkumferentna geometrija osvetljenja i 0° geometrija posmatranja. Uzorci su mereni kroz aperturu prečnika 3 mm. Kolorimetar je kalibrisan pomoću bele kalibracione pločice (CR-A45) koju proizvođač standardno isporučuje uz uređaj. U toku merenja, svaki uzorak je smešten u za tu svrhu izrađeni aluminijumski držač radi stablinosti merenja i konstantnog položaja uzoraka u odnosu na mernu aperturu.

facturer's instructions. An Epilar Trilight curing lamp (3M ESPE, St. Paul, MN) was used with an output of 900 mW/cm^2. The specimens were then stored in an incubator at 37°C for 24 hours to allow complete polymerization to occur.[13] Five specimens of each composite type were randomly placed into four groups:

- Mylar/Control (MC) no further manipulation.
- Prophy Cup/Paste (PCP) polished with Nupro prophy cup and Nupro "Extreme Bubble" medium grit polishing paste (Dentsply, Des Plains, IL) for 15 seconds using slow speed at 30 psi.
- Bur/Sof-lex Disc (BS) entire surface of specimen roughened with 12-fluted finishing bur (H48L-12, Brasseler USA, Savannah, GA), then polished using fine then extra-fine Sof-lex discs (3M ESPE, St. Paul, MN) for 30 seconds each.
- Bur/Sof-lex Disc/Prophy (BSP) equal to BS group and additional 15-second polish with prophy cup and paste (as in PCP group).

Colorimetric analysis was performed using a Minolta CR-321 photoelectric colorimeter (Minolta Camera Co. Ltd., Osaka, Japan).[14] The settings were D65 illuminant and a 2-degree standard observer, 45-degree circumferential illumination and 0-degree viewing angle. The specimens were measured through a 3-mm diameter measuring port. The colorimeter was calibrated using a white calibration plate (CR-A45) provided by the manufacturer. During measurement, each specimen was placed into a custom aluminum jig for stability and to center the measurement aperture on the specimen surface.

Razlike u boji (ΔE^*_{ab}) izračunavane su pomoću sledeće jednačine:[15]

$$\Delta E^*_{ab} = (\Delta L^{*2} + \Delta a^*_{ab}{}^2 + \Delta b^*_{ab}{}^2)^{1/2}$$

Sjajnost je merena korišćenjem glosmetra za male površine (Novo-Curve, Rhopoint Instrumentation, East Sussex, UK), kome je prethodno bio kalibrisan na 92.4 GU (jedinice sjajnosti) sa mernom površinom oblika kvadrata i dimenzija 2 × 2mm i geometrijom merenja od 60°. Uzorci su prilikom merenja postavljani u individualno izrađen kalup.

Srednja vrednost i standardna devijacija (n=5) izračunavani su analizom varijanse pomoću Statview programa (SAS Institute Inc. Cary, NC). Fisherov PLSD interval za razliku u boji izračunavani su za kompozite, metode poliranja i njihove interakcije na 0.05 nivou značajnosti. Fisherov PLSD interval izračunavan je i za sjajnost.

Rezultati

Prosečne ΔE^*_{ab} vrednosti između različitih kompozita za četiri metoda poliranja date su u tabeli 2. Razlike između A110 i ostala tri analizirana kompozita bile su najizraženije. Od preostala tri kompozita, A110 je bio najsličniji Z250 kompozitu, ΔE^*_{ab} = 6.7 (0.2) u BS grupi, a najviše se razlikovao od EXM 612 kompozita, ΔE^*_{ab}=10.4 (0.1) u MC grupi. Kompoziti Z 250 i P60 su bili najsličniji, ΔE^*_{ab} = 2.1 (0.3) u BS grupi. EXM 612 kompozit je bila najsličnija Z250 kompozitu, ΔE^*_{ab} = 3.2 (0.1) u MC grupi. Razlike u boji izmerene između parova

Color differences (ΔE^*_{ab}) were calculated using the following equation:[15]

$$\Delta E^*_{ab} = (\Delta L^{*2} + \Delta a^*_{ab}{}^2 + \Delta b^*_{ab}{}^2)^{1/2}$$

Gloss was measured using a small-area glossmeter (Novo-Curve, Rhopoint Instrumentation, East Sussex, UK), previously calibrated to 92.4 GU (gloss units) with a square measurement area of 2 × 2 mm and 60-degree geometry. The specimens were stabilized in a custom jig during measurement.

Means and standard deviations (n=5) were calculated by analysis of variance using Statview (SAS Institute Inc., Cary, NC). Fisher's PLSD intervals for color difference were calculated at the 0.05 level of significance for the effects of composites, polishing methods and their interactions. Fisher's PLSD intervals were also calculated for the gloss results.

Results

Average ΔE^*_{ab} values among the different composites for the four polishing methods are listed in table 2. A110 was the most dissimilar when compared to the other three composites tested. Of the three other resin composites, A110 was most similar to Z250, ΔE^*_{ab} = 6.7 (0.2) in the BS group. A110 was most different from the EXM 612 composite, ΔE^*_{ab} = 10.4 (0.1) in the MC group. Z250 and P60 were the least different from each other, ΔE^*_{ab} = 2.1 (0.3) in the BS group. The color of EXM 612 composite was most similar to Z250, ΔE^*_{ab} = 3.2 (0.1) in the MC group. The color differences measured bet-

Tabela 2. ΔE^*_{ab} vrednosti između kompozita u odnosu na ispitivane sisteme za poliranje*
Table 2. ΔE^*_{ab} values among composites, for evaluated polishing systems*

COMPOSITE	MC	PCP	BS	BSP
A110-Z250	7.9 (0.1)	7.2 (0.4)	6.7 (0.2)^{b}	6.8 (0.4)^{b}
A110-P60	8.5 (0.1)	8.0 (0.3)^{c,d}	8.1 (0.2)^{c}	7.9 (0.2)^{d}
A110-Nano	10.4 (0.1)	9.8 (0.3)	10.1 (0.2)^{e}	10.0 (0.4)^{e}
A250-P60	2.3 (0.1)^{f}	3.0 (0.8)	2.1 (0.3)	2.4 (0.3)^{f}
A250-Nano	3.2 (0.1)^{g}	3.3 (0.2)^{g}	3.8 (0.3)^{a}	3.6 (0.4)
P60-Nano	3.4 (0.1)	3.6 (0.7)^{h}	3.7 (0.4)^{a,h}	4.4 (0.4)

*Srednje vrednosti i standardna devijacija (n=25). Srednje vrednosti obeležene istim slovom u superskriptu su statistički jednake (p=0.05)
* Means and standard deviations (n=25). Means with the same superscripted letter are equal statistically (p=0.05)

kompozita, osim razlikâ između Z250 i P60, su bile statistički značajne (p < 0.0001, power 1.00).

Prosečne vrednosti ΔE^*_{ab} između različitih tehnika poliranja za četiri kompozita su date u tabeli 3. Sve ΔE^*_{ab} vrednosti su bile iznad praga koji označava "lošu usklađenost boja". Najviša ΔE^*_{ab} vrednost od 2.9 (0.3) je zabeležena između MC i BSP grupa za P60. ΔE^*_{ab} vrednosti između svih parova tehnika za poliranje su bile statistički različite, sa izuzetkom PCP i BSP grupa (p < 0.0001, power 1.00).

ween all pairs of composites, except for the difference between Z250 and P60, were statistically significant (p-value <0.0001, power 1.00).

Average ΔE^*_{ab} values among the different polishing techniques for the four composites are listed in table 3. All of the ΔE^*_{ab} values calculated were below the "poor color match" threshold of ΔE^*_{ab} = 3.7. The highest ΔE^*_{ab} value of 2.9 (0.3) was between MC and BSP groups for P60. The ΔE^*_{ab} values between all pairs of polishing techniques are statistically different, with the exception of PCP and BSP groups (p-value <0.0001, power 1.00).

Tabela 3. ΔE^*_{ab} vrednosti između različitih metoda poliranja i kontrolne grupe za ispitivane kompozite*
Table 3. ΔE^*_{ab} values among polishing methods and control group, for evaluated composites*

POLISHING METHODS	A110	Z250	P60	EXM 612
MC – PCP	0.6 (0.3)[a]	1.4 (0.6)	2.0 (0.9)	1.7 (0.4)
MC – BS	0.4 (0.2)[b]	2.0 (0.4)	1.2 (0.5)[d]	0.9 (0.3)[f]
MC – BSP	1.0 (0.4)	2.8 (0.4)[h]	2.9 (0.3)[h]	1.4 (0.5)
PCP – BS	0.4 (0.2)[b]	0.8 (0.6)[c,i]	1.1 (0.7)[d,e]	0.9 (0.4)[f,i]
PCP – BSP	0.6 (0.4)[a,j]	1.5 (0.7)	1.0 (0.8)[e]	0.6 (0.4)[g,j]
BS – BSP	0.8 (0.4)[k,l]	0.9 (0.4)[c,k]	1.7 (0.5)	0.7 (0.5)[g,l]

*Srednje vrednosti i standardna devijacija (n=25). Srednje vrednosti obeležene istim slovom u superskriptu su statistički jednake (p=0.05).
* Means and standard deviations (n=25). Means with the same superscripted letter are equal statistically (p=0.05).

Razlike u sjajnosti analiziranih kompozita i metoda poliranja (tabela 4) bile su značajne i među kompozitima i među tretmanima (p < 0.0001, power 1.00). Posle polimerizovanja kroz providnu matricu, sva četiri kompozita su imala visoku i statistički jednaku vrednost sjajnosti (p < 0.05). Najniže vrednosti sjajnosti

Gloss differences for the evaluated composites and polishing methods are listed in table 4 and they were significant among both composites and treatments (p<0.0001, power 1.00). After curing against Mylar surface, all four composites had high and statistically equal gloss values (p < 0.05). The lowest gloss values

Tabela 4. Vrednosti za sjajnost za ispitivane kompozite i sisteme za poliranje*
Table 4. Gloss (GU) values for composites and polishing methods*

COMPOSITE	MC	PCP	BS	BSP
A110	83.8 (2.3)[a]	60.1 (11.9)[b,g]	62.2 (11.6)[g]	35.9 (10.6)
A250	86.1 (4.8)[a]	64.6 (11.0)[b]	29.2 (6.2)[d]	11.1 (2.6)[f]
P60	85.7 (4.2)[a]	32.3 (16.7)[c,h]	33.1 (12.0)[d,e,h]	13.6 (2.1)[f]
EXM 612	84.8 (3.8)[a]	27.0 (5.0)[c]	37.6 (1.8)[e]	19.4 (6.6)

*Srednje vrednosti i standardna devijacija (n=25). Srednje vrednosti obeležene istim slovom u superskriptu su statistički jednake (p=0.05)
* Means and standard deviations (n=25). Means with the same superscripted letter are equal statistically (p=0.05)

bile su zabeležene za Z250 i P60 posle BSP. U poređenju sa vrednostima pre poliranja, prosečne vrednosti sjajnosti kod svih kompozita su nakon poliranja bile niže. Uzorci A110 kompozita su zadržali najviši stepen sjajnosti nezavisno od metoda poliranja u odnosu na ostale uzorke. Uzorci u BSP grupi su imali najniže vrednosti sjajnosti. Ovome treba dodati i da su nakon upotrebe gumice/paste uzorci A110 i Z250 imali znatno više vrednosti sjajnosti nego P60 ili EXM 612. A110 uzorci kompozita su sačuvali najviši stepen sjajnosti u toku sva tri tretmana. Nakon BS i BSP tretmana, vrednosti sjajnosti Z250 i P60 kompozita su bile statistički ekvivalentne ($p < 0.05$) početnim vrednostima (MC). Najniža stopa sjajnosti posle PCP tretmana zabeležena je za EXM 612, dok je Z250 imao najnižu sjajnost posle BS i BSP. A110 je imao višu, ili statistički jednaku stopu sjajnosti u poređenju sa ostalim kompozitima za svaki od ova tri tretmana.

Diskusija

Razlika u boji između A110 i ostala tri kompozita bila je viša od ΔE^*_{ab} između bilo kog para preostala tri kompozita. Kada se uporede A110 i Z250, ΔE^*_{ab} se kreće u rasponu od 6.8 (BSP) do 7.9(MC). Razlika između kompozita A110 i P60 bila je još veća i kretala se u rasponu od 7.0 (BSP) do 8.5 (MC) ΔE^*_{ab} jedinica. Razlika u boji između A110 i EXM 612 je bila najviša, uz opseg od 9.8 (PCP) do 10.4 (MC) ΔE^*_{ab} jedinica. Najniže ΔE^*_{ab} vrednosti registrovane su između Z250 i P60 i kretale su se od 2.1 (BS) do 3.0 (PCP). Razlika u boji između parova poređenih kompozita, izuzev između Z250 i P60, bile su iznad praga klinički prihvatljive usklađenosti boja ($\Delta E^*_{ab} \geq 3.7$).

Kada se razmotre svi metodi poliranja, razlika u boji je bila veoma mala, bez obzira na korišćeni metod. ΔE^*_{ab} vrednosti su kod svih poređenja bile najniže za A110, ispod $\Delta E^*_{ab} = 1.0$. Jedini izuzetak bio je za BS – BSP poređenje, sa najnižom ΔE^*_{ab} vrednošću za EXM 612. ΔE^*_{ab} vrednosti za A110 su se kretale od 0.4 (0.2) i za MC nasuprot BS i za PCP nasuprot

were for Z250 and P60 after BSP. Compared to Mylar, overall gloss values decreased for each composite upon manipulation. The specimens of A110 composite retained the most gloss regardless of polishing method, when compared with the other composites specimens. All composite specimens in the BSP group had the lowest gloss scores of their composite type. In addition, A110 and Z250 had significantly higher gloss values after prophy/paste than P60 or EXM 612. The A110 composite specimens retained the highest level of gloss throughout the three treatments. The Z250 and P60 composites had gloss measurements that were statistically equivalent ($p<0.05$) at the initial reading (MC), after BS treatment and after BSP treatment. The lowest gloss after the PCP treatment was recorded for EXM 612, while Z250 had the lowest gloss rating of the composites after both BS and BSP. A110 had higher, or statistically equal, gloss ratings compared to the other composites for each of the three treatments.

Discussion

The color difference between A110 and each of the other three composites was higher than ΔE^*_{ab} between any of the other three composites. When comparing A110 vs. Z250, ΔE^*_{ab} ranged from 6.8 (BSP) to 7.9 (MC). A110 vs. P60 difference was even higher, ranging from 7.0 (BSP) to 8.5 (MC) ΔE^*_{ab} units. And A110 vs. EXM 612 color difference was highest among the composite comparisons, ranging from 9.8 (PCP) to 10.4 (MC) ΔE^*_{ab} units. Z250 vs. P60 had the lowest overall ΔE^*_{ab} units, ranging from 2.1 (BS) to 3.0 (PCP). With the exception of the comparison between Z250 and P60, the color differences among the composite pairs are of such high ΔE^*_{ab} values as to represent clinically unacceptable color matches.

When all four polishing methods were considered, the difference in color was very small, regardless of the polishing method. In addition, the ΔE^*_{ab} for each comparison was lowest for A110, never reaching ΔE^*_{ab} of 1.0, with the exception of BS vs. BSP, whose lowest ΔE^*_{ab} value was for EXM 612. The ΔE^*_{ab} values for A110 ranged from 0.4 (0.2) for both

BS do 1.0(0.4) za MC nasuprot BSP. Najveća razlika u boji iznosila je 0.3 (0.2) za A110 između MC i BSP.

Kao što se moglo očekivati, vrednosti za sjajnost (GU) su se menjale u skladu sa tretmanima kompozita. GU vrednosti < 10 se smatraju niskom sjajnošću, vrednosti od 10 do 70 GU označavaju umerenu sjajnost, dok GU vrednosti >70 karakterišu visoku sjajnost. Postoje tri glavne merne geometrije za ispitivanje sjajnosti: 20˚, 60˚ i 85˚. Koja će od njih biti korišćena zavisi od GU vrednosti registrovanih pomoću 60˚ geometrije. Ako su zabeležene vrednosti (na 60˚) ispod 10 GU, treba koristiti 85˚ geometriju, za 10–70 GU (na 60˚) koristi se 60˚ geometrija; dok se za sjajnost > 70 GU (na 60˚) koristi 20˚ geometrija. Potpuno nereflektujuća površina imala bi sjajnost od 0 GU, a savršeno ogledalo bi imalo sjajnost od 100 GU na 60˚. Pošto je većina vrednosti dobijena poliranjem kompozita (stanje koje najbolje reflektuje kliničku praksu) između 10 i 70 GU, za ovu studiju je odabrana 60° geometrija, korišćena i u ranijim studijama. Standardizovanje uslova eksperimenata dalje opravdava upotrebu 60° geometrije za sve uzorke i sve faze eksperimenta.[16,17] U ovoj studiji sva četiri kompozita su imala visoku sjajnost (≥ 70 GU) nakon polimerizacije kroz transparentnu matricu, pre bilo kakvog poliranja ili mehaničkih promena. Sve ostale vrednosti su bile manje od 70 GU, a naročito za Z250, P60 i EXM 612 posle BSP (≤ 20 GU). Ovo pokazuje da je značajna količina sjajnosti izgubljena zbog promena u formi finiranja i profilaktičnog poliranja.

Pored poboljšanja estetske vrednosti nadoknade, dobro rubno zatvaranje i visoko ispolirana površina kompozita od suštinske su važnosti za zdravlje zuba i periodonta. Iako je površina polimerizovana preko transparentne matrice najglatkija, površina nadoknade i njene margine najčešće zahtevaju dodatno finiranje i poliranje. Neophodno je da stomatolog ovo zna i da ima pristup materijalima za poliranje koji omogućuju kreiranje i najglađih površina i margina. U međuvremenu, proizvođači teže da usavrše svoje kompozite u potrazi za materijalima čije karakteristike uključuju lakoću manipulacije, idealnu funkciju, estetičnost i

MC vs. BS and PCP vs. BS to 1.0 (0.4) for MC vs. BSP. The greatest color difference was for P60 between MC and BS, with a ΔE^*_{ab} of 2.1 (0.9). The smallest color difference was 0.3 (0.2) for A110 between MC and BSP.

As might be expected, gloss values (GU) changed as the composites were manipulated. A gloss value of < 10 is considered to be low in gloss, 10-70 is considered semi-gloss, and values of > 70 are considered to be high gloss. There are three main geometries for gloss measurements: 20°, 60° and 85°. The choice of which will be used actually depends on GU value obtained at 60°: if values recorded are under 10 GU, an 85° geometry should be used, for 10-70 GU a range of 60° is the most suitable, while if gloss of more than 70 GU is measured at 60°, a 20° geometry would be the most appropriate. For reference, a totally non-reflective surface will have 0 GU and a perfect mirror will read 1000 GU at 60°. Since the majority of the values obtained for the polished composites (the condition that is in best accordance with clinical practice) were in the 10-70 GU range, and because this geometry has been used in previous studies, 60° geometry was chosen for this study. Standardizing of experiment conditions further justifies the usage of the same (60°) geometry for all the specimens and all the phases.[16,17] In this study, all four composites had high gloss (≥70) after curing against a Mylar surface, prior to any polishing or mechanical manipulation. All other measurements were less than 70 GU, and, in particular, Z250, P60, and EXM 612 were ≤20 GU after BSP. This indicates that a significant amount of gloss was lost due to manipulation in the form of finishing and prophylaxis-type polishing.

In addition to its esthetic enhancement, a closed and highly polished composite surface and cavo-surface margin are essential to the dental and periodontal health of the tooth being restored. While the surface cured against a Mylar surface is the smoothest, the cavo-surface margin often requires finishing and polishing. This makes it important for the restoring dentist to understand and have access to polishing materials that recreate the smoothest possible surface and margin. In the meantime, manufacturers strive to perfect their composites, in pursuit of ones whose properties include ideal

mogućnost poliranja, koja je najčešće određena sastavom filera. Kompoziti ili sa veoma velikim ili veoma čvrstim česticama filera imaju veću hrapavost površine posle poliranja.[11] Pored veličine čestica, sadržaja filera, i abrazivnosti sistema za poliranje, filer takođe može da doprinese opaženoj poliranosti površina.[1] Kompoziti za frontalnu regiju se sastoje od relativno sitnih čestica za filer, koje utiču na poboljšanje polirabilnosti. Takozvani "Packable" kompoziti su koncipirani tako da olakšaju manipulaciju. Iako nijedan kompozit do sada nije dostigao idealne karakteristike za sve namene, poslednjih godina postignuti su značajni rezultati na tom planu. Imajući ovo na umu, četiri različita tipa kompozita (microfill, microhybrid, packable i nanofill) su u ovom istraživanju analizirani u odnosu na promenu boje i sjajnosti usled poliranja različitim sistemima i agensima.

Podaci o specifikaciji kompozita dobijeni su od strane proizvođača (tabela 1): A110 kompozit je estetski restaurativni mikrofilni materijal koga proizvođač preporučuje za upotrebu u direktnim i indirektnim nadoknadama u frontu. Proizvođač tvrdi da je filer kod Z250 kompozita suštinski isti kao kod Z100. Napredak je, prema proizvođaču, bio u promenama u proizvodnom ciklusu radi postizanja maksimalne konzistencije filera. Filer kod Filteka P60 kompozita za bočnu regiju sličnog je sastava kao kod Z250 i Z100. Nanofilni EXM-612 kompozit se proizvodi u dentin, body, enamel i incisal opacitetu, kao i u specijalizovanim pedijatrijskim i bleaching nijansama. Incizalne nijanse se sastoje od kombinacije neaglomeratornog/neagregatnog 75 nm silikatnog nanofilera i agregatnog silikatnog nanokluster filera (sa primarnom veličinom čestica od 75 nm). Veličina klustera se kreće od 0.6 do 1.4 μm. Dentin, body, enamel, pedijatrijske i bleaching nijanse se sastoje od sličnih cluster čestica filera veličine nanosilikata od 20 nm, koje sačinjavaju kluster od 0.6 do 1.4μm.

Rezultati ovog istraživanja pokazuju da je poliranjem znatno redukovana sjajnost testiranih kompozita. Kompozit sa najmanjom prosečnom veličinom čestica (A110) je zadržao najviši nivo sjajnosti kroz sva tri tretmana. Izmerene vrednosti sjajnosti kod Z250 i P60

handling, function, esthetics, and polishability. The filler composition of a composite often determines its polishability. Composites with either very large or significantly hard filler particles show greater surface roughness after polishing.[11] In addition to particle size, filler content, and the ability of the polishing system to abrade, the filler may also contribute to perceived polishability.[1] Anterior composites are composed of relatively small filler particles leading to improved polishability. Packable composites are designed for their ease in handling. While no single composite has achieved ideal properties for all applications, there have been many advances in recent years. With this in mind, four different composite types (microfill, microhybrid, packable, and a nanofill) were evaluated for color change and polishability as part of this study.

The following composite specifications were provided by the manufacturer (table 1): The A110 composite is an esthetic microfill restorative material that the manufacturer recommends for use in direct and indirect anterior restorations. The manufacturer claims the filler in Z250 restorative remains essentially the same as the 3M ESPE Z100 restorative material. An improvement, according to the manufacturer, has been in processing changes to maximize filler consistency. The filler in 3M ESPE Filtek P60 Posterior Restorative is of a similar makeup to that of Z250 and Z100. The nanofill EXM-612 composite, currently marketed as 3M ESPE Filtek Supreme Universal Restorative, is available in dentin, body, enamel, and incisal opacities, as well as in specialty pediatric and bleaching shades. The incisal shades contain a combination of a non-agglomerated/non-aggregated 75 nm silica nanofiller and an aggregated silica nanocluster filler (with a primary particle size of 75 nm). The cluster size range is 0.6 to 1.4 μm. The dentin, body, enamel, pediatric, and bleaching shades are comprised of similar cluster filler particles of 20 nm nanosilica that comprise clusters of 0.6 to 1.4 μm.

The data collected from this study reveal that polishing significantly affected gloss of the composites tested. The composite with the smallest average particle size (A110) retained the highest level of gloss throughout the three treatments. The gloss measurements of Z250 and P60 composites, each with average particle sizes of 0.6 μm, were statistically equivalent at

kompozita, svaki sa prosečnom veličinom čestice od 0.6μm, bile su statistički izjednačene kod MC, posle BS i posle BSP tretmana. Na osnovu rezultata ove studije nije moguće doneti zaključke u vezi sa efekatom dizajna čestica nanofilnog kompozita na zadržavanje njegove sjajnosti i polirabilnosti.

Studija je koncipirana tako da pruži korisne podatke kliničaru u vezi sa kolorimetrijskim određivanjem boja, kao i efekata rutinskog finiranja, poliranja i profilakse na boju i sjajnost kompozita. Buduća istraživanja bi mogla uključiti alternativni uređaj za merenje boje in vivo i primenu jednog takvog aparata za analizu pedijatrijskih ili bleaching nijansi. Takođe, bilo bi interesantno analizirati sjajnost nakon finiranja nekim budućim sistemima za poliranje, uporediti podatke.

Zaključak

Značajne razlike u boji su registrovane između različitih tipova kompozita istog proizvođača; A110 se najviše razlikovao od Z250, P60 i EXM 612. Utvrđeno je da finiranje i poliranje imaju statistički značajan uticaj na boju kompozita. Međutim, ova razlika u boji se teško može uočiti.

Razlike u sjajnosti između kompozita bile su pre finiranja i poliranja male.

Razlike u sjajnosti bile su merljive i uočljive kao i primetne razlike u sjaju u zavisnosti od metoda finiranja/poliranja i ove razlike su bile statistički značajne.

Zahvalnost

Zahvaljujemo kompanijama Brasseler USA za donaciju borera, 3M ESPE za donaciju diskova za poliranje i kompozita, kao i Jeff Spitzenbergeru zbog kreativne pomoći i izradi držača uzoraka.

Autori nemaju nikakav finansijski interes u odnosu na proizvode i od kompanija koje se u članku pominju.

the MC, after BS and after BSP treatment. It is not possible, with the data from this study, to conclude the effects of the particle design of the nanofill composite on its gloss retention or polishability.

This study was designed to provide useful information to the dental clinician regarding colorimetric shade selection as well as the effects of routine finishing, polishing, and prophylaxis on composite color and gloss. Subsequent studies may include an alternate color measuring device and its in vivo application for evaluation of pediatric or bleaching shades. Additionally, gloss may be evaluated after finishing with polishing systems new to the market since this study.

Conclusions

Significant color differences were found between the different composite types from the same manufacturer; A110 was the most different from Z250, P60 and EXM 612 composite tested. Finishing and polishing were found to have a statistically significant effect on the quantitative color of the composites. This color difference, however, is of such a magnitude that it would be unlikely to be noticed by the untrained human eye.

There were small differences in gloss among composites prior to finishing and polishing.

There were measurable, and visually noticeable, differences in gloss that were dependent upon the finishing/polishing method, and these differences were statistically significant.

Acknowledgments

Sincere appreciation is expressed to Brasseler USA for donating burs, 3M ESPE for donating polishing discs and all composite materials used in this study, and to Jeff Spitzenberger for his creative fabrication of the custom jigs.

The authors have no financial interest in the products or companies mentioned in this article.

LITERATURA / REFERENCES

1. Citron C. Esthetics in Pediatric Dentistry. NYSDJ 1995; 61(2):30–33.

2. Hunter RS. The measurement of appearance. New York: John Wiley & Sons, 1975, p. 42.

3. Bergen SF. Color in esthetics. NYSDJ 1985; 51:470–471.

4. Kim H, Um C. Color Differences Between Resin Composites and Shade Guides. Quintessence Int 1996; 27:559–567.

5. Yap AU. Color attributes and accuracy of Vita-based manufacturer's shade guides. Oper Dent 1998; 23:266–271.

6. Hotta M, Hirukawa H, Aono M. The effect of glaze on restorative glass-ionomer cements: evaluation of environmental durability in lactic acid solution. J Oral Rehabil 1995; 22:685–689.

7. Stanford W, Fan L, Wozniak W et al. Effect of finishing on color and gloss of composites with different fillers. Am Dent A J 1985; 110:211–213.

8. Kuehni FG, Marcus RT. An experiment in visual scaling of small color differences. Color Res Appl 1979; 4: 83–91.

9. O'Brien WJ, Groh CL, Banke KM. A new, small color difference equation for dental shades. J Dent Res 1990; 69:1762–1764.

10. Johnston WM, Kao EC. Assessment of appearance match by visual observation and clinical colorimetry. J Dent Res 1989; 68:819–822.

11. Roeder L, Tate W, Powers J. Effect of Finishing and Polishing Procedures on the Surface Roughness of Packable Composites. Oper Dent 2000; 25:534–543.

12. Neme AL, Frazier KB, Roeder LB, Debner TL. Effect of prophylactic polishing protocols on the surface roughness of esthetic restorative materials. Oper Dent 2002; 27:50–58.

13. Yap AU, Sau CW, Lye KW. Effects of finishing/polishing time on surface characteristics of tooth-colored restoratives. J Oral Rehabil 1998; 25:456–461.

14. Seghi RR, Johnston WM, O'Brien WJ. Performance Assessment of Colorimetric Devices on Dental Porcelains. J Dent Res 1989; 68:1755–1759.

15. Paravina RD, Powers JM, editors. Esthetic color training in dentistry. St. Louis: Mosby, 2004, *in press*.

16. Berns RS. Bilmeyer and Saltzman's Principles of Color Technology. 3rd ed., New York: John Wiley & Sons, 2000; pp.:31–74.

17. Sewell G. Measurement of gloss on curved surfaces. Surface World; 1997; Sep:21.

Adresa za korespondenciju / Address for correspondence:
Rade D. Paravina, D.D.S., M.S., Ph.D.
Scientist, Houston Biomaterial Research Center
Faculty Associate, Department of Restorative Dentistry and Biomaterials
University of Texas Dental Branch at Houston
6516 M.D. Anderson Boulevard, Room DBB 465
Houston, TX 77030-3402
U. S. A.

LeeAnn Walker, DDS, MS
Private Practice
4001 Garth Road, #104
Baytown, TX 77521
U.S.A.

STOMATOLOŠKI LINKOVI

DENTAL LINKS

Journal of the Canadian Dental Association (JCDA).
http://www.cda-adc.ca/jcda

Journal of Contemporary Dental Practice..
http://www.dentalcare1.com/docs/soap/journals/contemp/issue001/index.htm

Journal of the American Dental Association (JADA).
http://www.ada.org/adapco/jada/j-menu.html

Journal of Dental Research.
http://www.iadr.com/jdr/jdr.html

British Dental Journal.
http://www.bdj.co.uk/

Australian Dental Journal.
http://www.ada.org.au/publications/journal.htm

Norwegian Dental Journal.
http://www.tannlegeforeningen.no/main.htm

Brazilian Dental Journal.
http://www.forp.usp.br/bdj/bdj.htm

Canadian Medical Association Journal (CMAJ) and Journal of the American Medical Association (JAMA).
http://www.cma.ca/cmaj/index.asp http://jama.ama-assn.org/

International Journal of Paediatric Dentistry.
http://www.blacksci.co.uk/products/journals/ijpd.htm