ACTA
STOMATOLOGICA
CROATICA
www.ascro.net

Acta Stomatol Croat. 2006; 40: 65-71.

IZVORNI ZNANSTVENI RAD
ORIGINAL SCIENTIFIC PAPER

Marko Jakovac[1], Jasenka Živko-Babić[1], Lidija Ćurković[2], Andreja Carek[1]

Kemijska postojanost dentalnih keramika u kiselom mediju

Chemical Durability of Dental Ceramic Material in Acid Medium

[1] Zavod za stomatološku protetiku Stomatološkog fakulteta Sveučilišta u Zagrebu, Gundulićeva 5, Zagreb
Department of Prosthodontics, School of Dental Medicine, University of Zagreb, Zagreb, Croatia
[2] Zavod za materijale Fakulteta strojarstva i brodogradnje Sveučilišta u Zagrebu.
Department of Materials, School of Engineering, University of Zagreb, Zagreb, Croatia

Sažetak
Stomatološki materijali moraju se ispitati prema strogim kriterijima kako bi se odredila njihova dugotrajna terapijska vrijednost. Kemijska degradacija dentalne keramike povećava njezinu hrapavost i istodobno trošenje antagonističkog zuba ili restorativnog materijala, povećava prianjanje plaka na keramiku, oslabljuje strukturu keramike uzrokujući kritičnu izmjenu iona na njezinoj površini i povećava osjetljivost keramike na buduće kemijske agense. Svrha rada bila je ispitati gubitak mase uzoraka četiriju različitih dentalnih keramika u kiselom mediju. Najmanji gubitak mase izmjeren je kod apatitne staklo-keramike (IPS-Empress 2 za slojevanje) (4,9±0,3 μg/cm^2), a najveći kod glinične keramike (Vitadur alpha) (15,0±0,2 μg/cm^2). Litijska disilikatna staklo-keramika (IPS-Empress 2 za bojenje) i glinična (IPS-Classic) pokazale su vrlo slične rezultate (9,4±3,4 μg/cm^2 i 10,1±0,3 μg/cm^2). Vrijednosti gubitka mase uzoraka u ovom radu, kao i u većini pronađenih u literaturi, minimalne su, te vjerojatno nemaju kliničke i toksikološke posljedice. Ali, to ne znači da se mogu uopćavati i prenositi na neispitane vrste dentalne keramike.

Zaprimljen: 20. prosinca 2005.
Prihvaćen: 16. veljače 2006.

Adresa za dopisivanje
Mr. sc. Marko Jakovac, dr. stom.
Zavod za stomatološku protetiku
Stomatološki fakultet
Sveučilište u Zagrebu
Gundulićeva 5, 10000 Zagreb
jakovac@sfzg.hr
Tel.: 014802135

Ključne riječi
Kemijska postojanost, glinična keramika, staklo keramika.

Uvod

Stomatološki materijali moraju se ispitati prema strogim kriterijima kako bi se odredila njihova dugotrajna terapijska vrijednost. Jedno od najvažnijih svojstava svakoga restorativnog materijala jest njegova biološka inertnost. Inertnost materijala ovisi o strukturi, sastavu, laboratorijskoj obradi te okolini koja na njega utječe. Inertnost nekog materijala može se opisati i njegovom kemijskom degradacijom.

Kemijska degradacija dentalne keramike povećava njezinu hrapavost i istodobno trošenje antagonističkog zuba ili restorativnog materijala, povećava prianjanje plaka na keramiku, oslabljuje strukturu keramike uzrokujući kritičnu izmjenu iona na po-

Introduction

Dental materials need to be thoroughly examined in order to assess their therapeutic value. One of the most important properties of a restorative material is that it is biologically inert. This property depends on the structure, composition, laboratory handling and the environment having its effect on the material. It can also be described by means of chemical degradation.

Chemical degradation of dental ceramic materials enhances its roughness leading to the wear of the opposing natural tooth or restorative material, greater plaque attachment to ceramics, weakening of the ceramic structure causing the critical ion exvršini i povećava osjetljivost keramike na buduće kemijske agense. Kod nekih vrsta keramika kemijski i mehanički utjecaj na površinu pojačava njezinu strukturu smanjenjem izmjene iona (1).

Unatoč svim spoznajama, još nije do kraja poznato ponašanje dentalnih gradivnih materijala u usnoj šupljini. Postoji niz različitih metoda ispitivanja kemijske postojanosti restorativnih materijala. Dvije najzastupljenije su ispitivanje prema standardima ISO (2) i ADA (3). U spomenutim metodama koristi se 4% octena kiselina kao medij koji ubrzava degradaciju keramike, a ispituje se gubitak mase uzoraka keramike nakon imerzije. Osim tih metoda postoji i mnogo drugih kojima se pokušalo detaljnije, jednostavnije i dugotrajnije (4-11) ispitati kemijsku postojanost restorativnih materijala. U svim tim metodama mijenja se medij u kojemu se ispituje degradacija keramike, vrijeme ispitivanja te rezultati koji se izražavaju kao ukupni gubitak mase ili gubitak pojedinih iona iz uzoraka keramike.

Svrha rada bila je ispitati kemijsku inertnost četiriju različitih vrsta dentalne keramike u kiselom mediju.

Materijali i metode

Uzorci četiriju vrsta dentalne keramike (Tablica 1) izrađeni su u kalupu od pleksiglasa dimenzija 10x10x2 mm, u obliku pločica. Ispitivane dentalne keramike priređene su prema uputama proizvođača. Tijekom izrade uzoraka glinične keramike koristio se kalup od pleksiglasa u kojemu se kondenzirala keramička smjesa. Nakon kondenzacije uzorci su prebačeni na foliju i preneseni u standardne peći za keramiku. U izradi uzoraka od staklokeramike IPS Empress 2, kalup je poslužio za uzorke od voska koji su se nakon toga ulagali u kivete i iz njih su tlačnim postupkom dobiveni željeni uzorci. Kako je smjernica u ispitivanju bio standard ISO 6872 (2), za ispitivanje postojanosti dentalne keramike izrađeno je po deset uzoraka od svake vrste keramike. Svi uzorci glazirani su po cijeloj površini, ka-

change at the surface and enhancing the sensitivity to future chemical agents. In some ceramic materials, the chemical and mechanical influence on the surface enhances it by lowering the rate of ion exchange (1).

Despite of all the knowledge, the properties of dental ceramic materials in oral cavity are still not completely understood. There are many different examination methods of chemical durability of restorative materials; two most frequently used being the methods according to ISO (2) and ADA (3) standards. These two methods use 4% acetic acid as a medium that speeds up the degradation process, and later analyze the mass loss of the samples after immersion. There are different methods that tried to analyze the chemical durability in more detail, simpler or longer (4-11). All these methods differ in medium that is used in degradation analysis, time of analysis and the results that are expressed either as a mass loss or loss of specific ions in the samples.

The aim of this study was to assess the chemical stability of four different dental ceramic materials in an acid medium.

Material and methods

Samples of four types of dental ceramic material (table 1) were constructed in a Plexiglas cast (10×10×2 mm). The tested dental ceramic materials were prepared according to the manufacturer's instructions. When preparing samples of alumina ceramics we used a cast made of Plexiglas in which the ceramic mix was condensed. After condensation the samples were transferred to foil and to standard ceramic ovens. When preparing samples of IPS Empress 2 glass ceramics the cast was used for wax samples that were cuvetted and from which we obtained the ceramic samples under pressurized procedure. Since the guideline in this study was ISO standard 6782 (2) for assessing the durability of dental ceramic materials, we manufactured ten samples of each ceramic material. All samples were complete-

Tablica 1. Ispitivane vrste dentalne keramike
Table 1. Tested dental ceramic materials

Skupina uzoraka • Sample group	Tvornički naziv • Product name	Proizvođač • Manufacturer	Vrsta keramike • Type of ceramic material
1	Vitadur alpha	Vita-Zahnfabrik, Bad Säckingen Rosbach, Germany	glinična keramika • Alumina ceramic
2	IPS –Classic	Ivoclar Vivadent, Schaan, Liechtenstein	glinična keramika • Alumina ceramic
3	IPS Empress 2	Ivoclar Vivadent, Schaan, Liechtenstein -za tehniku slojevanja • for layering technique	apatitna staklo-keramika • Apatite glass ceramic
4	IPS Empress 2	Ivoclar Vivadent, Schaan, Liechtenstein -za tehniku bojanja • for colouring technique	litijska disilikatna staklo-keramika • Lithium-disilicate glass ceramic

ko bi bili što vjerodostojniji radovima koji se unose u usta.

Uzorci su oprani destiliranom vodom u ultrazvučnoj kupelji (UltraSonic Bath Model 1510 DTH, Electron Microscopy Sciences, Hatfield, SAD) i četiri sata sušeni u sterilizatoru (Sterilizator, Instrumentarija, Zagreb, Hrvatska) na temperaturi od 150 ± 5ºC. Nakon određivanja mase uzoraka s točnošću mjerenja od ± 10^{-5} g (analitička vaga, Ohous, Analytical plus), svaki je uzorak uronjen u 25,0 mL otopine CH_3COOH (4%) u plastičnu bočicu PP (polipropilensku). Bočice su stavljene u termostatiranu mućkalicu (INNOVA 4080 INCUBATOR-SHAKER, Herisau, Švicarska) na temperaturu od 80º C s brzinom okretaja od 200 o/min tijekom 16 sati. Nakon toga su izvađeni i oprani destiliranom vodom u ultrazvučnoj kupelji (ISO 3696), četiri sata sušeni u sterilizatoru na 150 ± 5 ºC te izvagani.

Rezultati su opisani deskriptivnom statistikom i testom Mann-Whitney.

Rezultati

Mann-Whitneyevim testom usporedile su se po dvije nezavisne skupine uzoraka. Usporedbom su izračunati gubici mase svih skupina uzoraka. Iz Tablice 2 vidi se da su gubici mase uzoraka međusobno statistički znatno različiti ($p < 0,05$). Tablica 3 pokazuje rezultate deskriptivne statistike za

ly glazed in order to represent the prosthetic work more accurately.

Samples were washed in distilled water in an ultrasonic bath (UltraSonic Bath Model 1510 DTH, Electron Microscopy Sciences, Hatfield, USA) and dried in a sterilizing unit (Sterilizator, Instrumentarija, Zagreb, Croatia) at 150±5°C during four hours. After determining the mass of the sample with the accuracy of ±10^{-5} g (analytic scale, Ohous, Analytical plus), each sample was immersed in 25 ml of 4% CH_3COOH solution in a polypropilene bottle. The bottles were placed in a thermostatic shaker (Innova 4080 Incubator-shaker, Herisau, Switzerland) at 80°C with 200 rpm for 16 hours. After the time has elapsed, the samples were washed with distilled water in an ultrasonic bath (ISO 3696) and dried in a sterilizing unit at 150±5°C during four hours, and weighed.

The results are described by descriptive statistics and Mann-Whitney test.

Results

Two independent groups of samples were compared by means of Mann-Whitney test. We compared the calculated losses of mass of all groups of samples. Table 2 clearly depicts that the mass losses of the samples are statistically significantly different ($p < 0.05$). Table 3 depicts the results of de-

Tablica 2. Mann-Whitneyev test za usporedbu nezavisnih skupina (skupine uzoraka opisane su u Tablici 1.)
Table 2. Mann-Whitney test for comparison of independent groups (sample groups were described in Table 1)

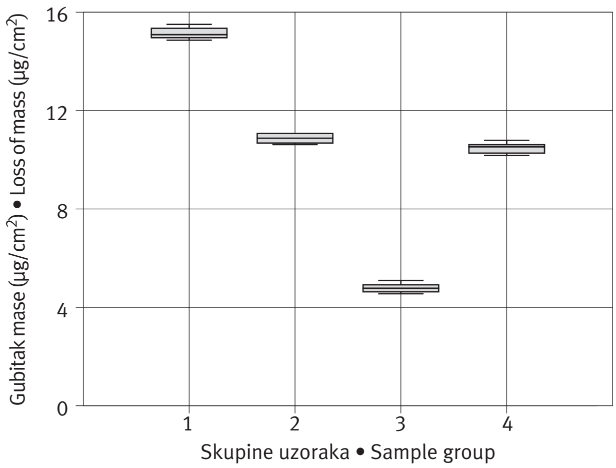
Usporedba skupina uzoraka • Comparison of sample groups	Mann-Whitney U	Z	p
1 - 2	0	-3,368	0,001
1 - 3	0	-3,371	0,001
1 - 4	0	-3,368	0,001
2 - 3	8	-2,526	0,012
2 - 4	11,5	-2,162	0,031
3 - 4	0	-3,368	0,001

Tablica 3. Deskriptivna statistika (µg/cm2) (skupine uzoraka opisane su u Tablici 1.)
Table 3. Descriptive statistics (µg/cm2). Sample groups were described in Table 1.

Skupina uzoraka • Sample group	Aritmetička sredina • Arithmetic mean	Standardna devijacija • Standard deviation	Min	Max
	Medijan • Median	Interkvartilni raspon • Interquartile range	25 percentila • 25th percentile	75 percentila • 75th percentile
1	15,0	0,2	14,7	15,3
	14,9	0,4	14,8	15,2
2	9,4	3,4	1,0	10,8
	10,6	0,5	10,3	10,8
3	4,9	0,3	4,6	5,3
	4,9	0,4	4,7	5,1
4	10,1	0,3	9,7	10,5
	10,1	0,5	9,8	10,3

sve skupine uzoraka. Rezultati ispitivanja grafički su prikazani na Slici 1. Najmanji gubitak mase izmjeren je kod apatitne staklo-keramike (4,9±0,3 µg/cm^2), a najveći kod glinične keramike (Vitadur alpha) (15,0±0,2 µg/cm^2). Zanimljivo je da litijska disilikatna staklo-keramika i glinična (IPS-Classic) pokazuju vrlo slične rezultate (9,4±3,4 µg/cm^2 i 10,1±0,3 µg/cm^2).

scriptive statistics for all sample groups. The results of the testing are depicted in figure 1. The smallest mass loss was measured for apatite glass ceramics (4.9±0.3 µg/cm^2), and the greatest for alumina ceramics (15±0.2 µg/cm^2). It is interesting that lithium-disilicate ceramics and alumina ceramics (IPS Classic) show very similar results (9.4±3.4 µg/cm^2 and 10.1±0.3 µg/cm^2).



Slika 1. Grafički prikaz gubitka mase uzoraka (µg/cm2) ovisno o skupini uzoraka (opisane u Tablici 1.).
Figure 1. Graphic depiction of loss of mass of samples (µg/cm2), depending on sample group (as described in Table 1).

Rasprava

Degradacijom u usnoj šupljini zbog mehaničkih i kemijskih utjecaja ili njihove kombinacije, postaju upitna početna svojstva keramike. U praksi su ti utjecaji nedjeljivi te oni zajednički djeluju na svaki protetski rad, pa tako i keramički. S obzirom na to da se u literaturi najčešće spominju ispitivanja samo mehaničkoga ili samo kemijskog utjecaja na gradivni materijal, postavlja se pitanje degradira li njihov zajednički utjecaj jače ili slabije gradivni materijal, negoli kad se zbroje ispitivanja tih pojedinačnih utjecaja. Odgovor na to pitanje dali su White i suradnici (12) – oni su u svojem radu dokazali da se njihov zajednički utjecaj ne razlikuje znatno od njihova zbroja te da je time moguće odvojeno promatrati kemijsko i mehaničko djelovanje na gradivni materijal.

Ako se gleda samo kemijski učinak, usna šupljina je vrlo agresivna sredina za svaki dentalni materijal. U prvom redu stalno se mijenja pH vrijednost sline, ovisno o unosu hrane, količini plaka, sastavu sline te kiselosti želučanog soka. Zatim, dokazano je da se keramičkom materijalu u vodenoj sredini smanjuje otpornost na pucanje. Osim smanjenja mehaničkih svojstava, korozijski procesi uzrokuju sve veću hrapavost površine nekih keramika, a time i veću adheziju plaka (5, 13), povećanje tro-

Discussion

Degradation in the oral cavity due to mechanical or chemical influences, or their combination, challenges the initial properties of dental ceramics. In practice, these influences are inseparable, so they exhibit synergistic effect on every prosthetic restoration, including ceramic ones. Since the literature mentions studies on only mechanical, or only chemical, influence, a question whether their synergistic influence causes more or less material degradation can be raised. White et al. gave an answer to that question (12), proving that combined influences do not have different outcome when compared to their addition, lending credence to the fact that separate monitoring of chemical and mechanical on the materials is possible.

If only chemical influence is monitored, one can realize that oral cavity represents a rather aggressive environment for every dental material. The acidity of saliva is constantly changing, depending on food intake, amount of plaque, saliva composition and acidity of the gastric juice. It has been proven that the fracture resistance of ceramic material in aqueous environment decreases. With degradation of mechanical properties, corrosion processes increase the roughness of the surface of some ceramic materials, thus enhancing plaque adhesion šenja antagonističkih zuba i materijala te promjenu boje, pa time narušavaju i estetiku keramičkoga protetskog rada (1). Uz to, čak i minimalne promjene u hrapavosti površine mogu uzrokovati promjene u interakciji između keramičke površine i biološke okoline. Nadalje, moguće smanjenje kemijske stabilnosti keramike može pogodovati daljnjem otpuštanju anorganskih iona i drugih sastojaka koje mogu biti potencijalno toksične (npr. litij iz litijske staklo-keramike).

Procese korozije dentalnih materijala potrebno je bolje analizirati i razumjeti, kako bi se mogla predvidjeti trajnost materijala i njegova dugoročna biokompatibilnost. Bez obzira na to što se dentalna keramika smatra više-manje inertnim materijalom, ne smiju se previdjeti mogući učinci produkata korozije na biološki sustav. Sigurnost u jednu vrstu ispitane keramike ne smije se prenositi na druge neispitane vrste te na druge uvjete u kojima se nalaze (1, 5).

U ispitivanju kemijske postojanosti često se koriste različite kiseline, kao npr. klorovodična (4) ili octena (2). Prednosti korištenja kiselina umjesto umjetne sline ili destilirane vode jesu u ubrzanju korozijskih procesa, tj. materijal se brže degradira nego u umjetnoj slini i vodi i u želji za što boljom predikcijom dugoročne postojanosti keramike u ustima. S umjetnom slinom i vodom ispitivanja bi trajala godinama, a rabimo li kiselinu traju puno kraće. Pojedini autori (4) tijekom ispitivanja kemijske postojanosti žele obuhvatiti i zbivanja u usnoj šupljini koja se događaju pri nižem pH, jer je poznato da pH u ustima varira i u nekim slučajevima je vrlo nizak, kao kod različitih želučanih tegoba. Iz tih razloga i standard ISO 6872 (2), koji se odnosi na kemijsku postojanost dentalne keramike, koristi se 4% octenom kiselinom kao otopinom u ispitivanjima spomenute postojanosti. U ovom radu rabila se octena kiselina koja je - osim zbog standarda ISO - i najčešće korištena kiselina u kućanstvu. Na izbor je isto tako utjecala i pH vrijednost (pH = 2,4), jer odgovara vrijednosti pH nekih osvježavajućih pića i voćnih sokova te vrijednosti koja je ustanovljena na mjestima ispod plaka u ustima. Iako je octena kiselina slaba organska kiselina, ona je još dovoljno korozivna za staklo, jer stvara topljive komplekse (5).

Rezultati studije pokazuju da apatitna staklo-keramika (4,9±0,3 $\mu g/cm^2$) gubi na težini tri puta manje od glinične keramika (Vitadur alpha) (15,0±0,2 $\mu g/cm^2$). Litijska disilikatna staklo-keramika i glinična (IPS-Classic) pokazuju vrlo slične rezultate (9,4±3,4 $\mu g/cm^2$ i 10,1±0,3 $\mu g/cm^2$). Zanimlji-

(5, 13); corrosion increases the wear of antagonistic teeth and material and change of color, thus diminishing the esthetic outcome of the ceramic restoration (1). Even minute changes in surface roughness can cause changes in interaction between the ceramic surface and the environment. Furthermore, possible decrease of chemical stability of the ceramic material can contribute to advanced dissemination of anorganic ions and other components that can potentially be toxic (for example, lithium from lithium-glass ceramics).

Corrosion of dental materials must be known and understood in order to foresee the durability of the material and its long-term biocompatibility. Although dental ceramic materials are considered to be inert, possible effects of corrosion products on the biological system cannot be overlooked. Safety of the tested ceramic material cannot be transferred to other types that were not tested, and it cannot be transferred to other conditions (1, 5).

Different acids are often used for testing chemical durability, such as hydrochloric acid (4), or acetic acid (2). The advantages of acids when compared to artificial saliva or distilled water is the speed of the corrosion, i.e. faster degradation of materials, and the wish for better prediction of the durability of the ceramic material in the mouth. Tests with artificial saliva or distilled water would last for years, whereas acid tests are much shorter. Some authors (4) like to include the processes in the oral cavity occurring at much greater acidity when testing the durability of the material; it is well known that the acidity of the mouth varies and in some cases, like, for example, in patients with gastric symptoms, the acidity can be very high. For these reasons ISO standard 6872 (2), which is related to chemical durability of dental ceramic materials, uses 4% acidic acid for testing. This study used acetic acid, which, apart from ISO standardization, is the most widely used acid. The acidity level (pH = 2.4) is the same as in some refreshing drinks and fruit juices, as well as the level that has been established in plaque. Although acetic acid is a weak organic acid, it is still corrosive enough for glass by establishing soluble complexes (5).

The results of this study show that apatite glass ceramic material (4.9±0.3 $\mu g/cm^2$) loses three times less mass than alumina ceramics (Vitadur alpha, 15±0.2 $\mu g/cm^2$). Lithium-disilicate glass ceramic material and alumina (IPS-Classic) ceramic material show similar results (9.4±3.4 $\mu g/cm^2$ and 10.1±0.3 $\mu g/cm^2$). It is interesting to note that apavo je da apatitna keramika ima gotovo dvostruko bolje rezultate od litijske disilikatne staklo-keramike, iako dijele isto tvorničko ime. Isto tako znatne su razlike između gubitka mase uzoraka IPS-Classic i alpha keramike Vitadur, iako obje po kemijskom sastavu pripadaju gliničnim keramikama. No, treba istaknuti da su sve dobivene vrijednosti gubitka mase uzoraka daleko ispod 2000 µg/cm^2, koliki je maksimalni dopušteni gubitak mase uzoraka prema standardu ISO broj 6872 , koji vrijedi za sve keramičke materijale (2).

Grossman i Walters (8) izvijestili su o gubitku mase keramike Dicor koja u 4% octenoj kiselini na 80ºC iznosi 4,2 x 10^{-3} mg/cm^2 na dan. Usporedbe radi - kemijska trajnost keramike Vitadur bila je 16,5 x 10^{-3} mg/cm^2 na dan, aluminijskog-oksidnog materijala Vitadur za tvrde jezgre 20,0 x 10^{-3} mg/cm^2 na dan i keramike Ceramco 9,5 x 10^{-3} mg/cm^2 na dan.

Anusavice (1) je izračunao da je maksimalno otpuštanje iona iz 32 keramička zuba u octenoj kiselini na 80ºC oko 0,1 mg/na dan. Utvrđena dubina prodora oštećenja keramike nakon jedne godine bila je samo 0,3 µm za staklo-keramiku i 1,4 µm za Vitadur N opaker.

Ispitivanje Esquivel-Upshawa i suradnika (7) pokazalo je da je od tri ispitivane vrste keramike, IPS Empress najnestabilniji glede boje i savijne čvrstoće, a kemijska postojanost In-Cerama nije zadovoljavala čak ni standard ADA broj 69 (3). Procera, kao treći ispitivani materijal za tvrde jezgre, pokazao je najbolje vrijednosti kemijske stabilnosti i mehaničke čvrstoće.

Iako su tijekom ispitivanja nađene izrazito male vrijednosti gubitka mase uzoraka, to svakako ne znači da su iste vrijednosti i za sve dentalne keramike na tržištu. Ispitivanje bi trebalo provesti tako da je keramika dulje izložena octenoj kiselini, kako uostalom sugerira i De Rijk sa suradnicima (6).

Zaključci

1. Različite vrste keramika imaju različite vrijednosti gubitka mase, bez obzira na sličnost kemijskog sastava ili tvorničkog imena.
2. Vrijednosti gubitka mase uzoraka bile su minimalne.
3. Dobivene vrijednosti gubitka mase uzoraka vrlo vjerojatno nemaju kliničke i toksikološke posljedice.
4. Dobivene vrijednosti gubitka mase uzoraka ne mogu se uopćavati i prenositi na neispitane vrste dentalne keramike.

tite ceramics has almost twice as good results than lithium-disilicate, although they share the same production name. There are also significant differences in mass loss between samples of IPS-Classic and Vitadur alpha ceramic materials, although both of these materials fall into the group of alumina materials. It must be stressed that all values of mass loss fall well below 2000 µg/cm^2 that is the set limit according to ISO standards No. 6872 that is valid for all ceramic materials (2).

Grossman and Walters (8) reported on loss of mass of Dicor ceramic material that in 4% acetic acid at 80°C amounts to 4.2×10^{-3} mg/cm^2 daily. Chemical durability of Vitadur ceramic material was 16.5×10^{-3} mg/cm^2 daily, of Vitadur aluminum-oxide material for hard shells 20×10^{-3} mg/cm^2, and of Ceramco alumina ceramic material 9.5×10-3 mg/cm^2.

Anusavice (1) has computed that the maximum ion release from 32 ceramic teeth in acetic acid at 80°C amounts to 0.1 mg daily. The established depth of the penetration defect in ceramic material after one year was only 0.3 µm for glass ceramics and 1.4 µg for Vitadur N opaquer.

The study by Esquivel-Upshaw et al. (7) showed that out of three tested ceramic materials IPS Empress was the least stable with regards to the color and flexural strength, while the chemical durability of In-Ceram was not acceptable even for ADA Standard No. 69 (3). Procera, as the third tested material for copings, showed the best values of chemical durability and mechanical toughness.

Although there were minute values of mass loss of the samples, it does not imply that the values are the same for all dental ceramic materials on the market. The testing should be done over a longer time period, as suggested by De Rijk et al (6).

Conclusion

1. Different ceramic materials have different values of loss of mass, without regards to the similarity of chemical composition of product name.
2. Losses of mass values were minimal.
3. The established values most probably do not have any clinical or toxicological consequences.
4. The values cannot be generalized and cannot be transferred to dental ceramic materials that were not tested.

Zahvala

Rad je pripremljen u sklopu znanstvenog projekta "Protetski materijali", broj 0065100, a financiralo ga je Ministarstvo znanosti, obrazovanja i športa Republike Hrvatske.

Acknowledgment

This study was performed as a part of a scientific project "Dental prosthetic materials" grant No. 0065100, financed by the Ministry of Science, Education and Sports of the Republic of Croatia.

Abstract

Dental materials need to be thoroughly examined in order to assess their long-term therapeutical value. Chemical degradation of dental ceramic material enhances its roughness, leading to the wear of the opposing natural tooth or restorative material, greater plaque attachment to ceramics, weakening of the ceramic structure causing the critical ion exchange at the surface and enhancing the sensitivity to future chemical agents. The aim of this study was to test loss of mass in samples of four different dental ceramic materials in an acid medium. The least mass loss was recorded in apatite glass ceramic (IPS-Empress 2 for layering) (4.9±0.3 μg/cm^2), and most mass loss was recorded in alumina ceramic (Vitadur alpha) (15±0.2 μg/cm^2). Lithium disilicate glass ceramic (IPS-Empress 2 for coloring) and alumina (IPS-Classic) showed very similar results (9.4±3.4 μg/cm^2 and 10.1±0.3 μg/cm^2). The values of mass loss in samples in this work, as well as in the most of the literature, are minimal and presumably do not have any clinical or toxicological effects. However, it does not imply that these values can be generalized and transferred to dental ceramic materials that were not yet analyzed.

Received: December 20, 2005
Accepted: February 16, 2006

Address for correspondence
Marko Jakovac DDS, MS
Department of Prosthodontics
School of Dental Medicine
University of Zagreb
HR-10000 Zagreb, Croatia
jakovac@sfzg.hr
Phone: +38514802135

Key words
Ceramics, Dental Restoration Wear.

References

1. Anusavice KJ. Degradability of dental ceramics. Adv Dent Res. 1992; 6: 82-9.
2. International Organization for Standardization. ISO 6872 international standards for dental ceramics. Geneva: International Organization for Standardization; 1995.
3. American National Standard / American Dental Association. Specification No. 69., Dental ceramics. Chicago: Council on Dental Materials, Instruments and Equipment; 1991.
4. Živko-Babić J, Ćurković L, Ivaniš T, Pandurić J, Borić D. Chemical stability of feldspatic and hydrothermal ceramics. In: The proceeding of 24th annual conference EPA 2000. Gröningen: EPA; 2000. p. 93.
5. Milleding P, Wennerberg A, Alaeddin S, Karlsson S, Simon E. Surface corrosion of dental ceramics *in vitro*. Biomaterials. 1999; 20(8): 733-46.
6. De Rijk WG, Jennings KA, Menis DL. A comparison of chemical durability of test solutions for dental porcelains. In: The proceedings, Southern Biomedical Engineering Conference, 1985. New York: Pergamon; 1985. p. 152-5.
7. Esquivel-Upshaw JF, Chai J, Sansano S, Shonberg D. Resistance to staining, flexural strength, and chemical solubility of core porcelains for all-ceramic crowns. Int J Prosthodont. 2001; 14(3): 284-8.
8. Grossman DG, Walters HV. The chemical durability of dental ceramics. J Dent Res. 1984; 63: 234.
9. Anusavice KJ, Zhang NZ. Chemical durability of Dicor and lithia-based glass-ceramics. Dent Mater. 1997; 13(1): 13-9.
10. Živko-Babić J, Ćurković L, Jakovac M. Chemical durability of alumina dental ceramic. In: Proceedings of 17th International Research/Expert Conference, 2003. Barcelona: 2003. p. 257-9.
11. Jakovac M, Živko-Babić J, Ćurković L, Aurer A. Mesurament of ions release from dental ceramics. In: Proceedings of the 28th Annual Conference of EPA 2004. Izmir: EPA; 2004. p. 102.
12. White SN, Li ZC, Yu Z, Kipnis V. Relationship between static chemical and cyclic mechanical fatigue in feldspathic porcelain. Dent Mater. 1997; 13(2): 103-10.
13. Castellani D, Bechelli C, Tiscione E, Lo Nostro A, Pierleoni PP. *In vivo* plaque formation on cast ceramic (Dicor) and conventional ceramic. Int J Prosthodont. 1996; 9(5): 459-65.