**Sažetak**
Staklenoionomerni cementi često se primjenjuju u kliničkoj praksi zbog niza pozitivnih svojstava – kemijskog vezivanja na tvrda zubna tkiva, otpuštanja fluorida, koeficijenta toplinske ekspanzije sličnih koeficijentu zuba, ne zahtijevaju potpuno suho radno polje, manje su volumetrijske kontrakcije te zadržavaju dubu stabilnost boje. Fizička svojstva mogu se poboljšati upotrebom vanjske energije kao što su ultrazvuk i toplina koji ujedno olakšavaju kemijski proces stvarnjanja. **Svrač**: Željela se usporediti hrapavost površine staklenoionomernih cementa tretiranih grijanjem (engl. *thermo-curing*) i bez grijanja te ustanoviti koja je tehnika poliranja učinkovitija. **Materijali i metode:** Dva polirajuća sustava (volfram-karbidna svrdla i diskovi Sof-Lex) korištena su za dvije vrste staklenoionomer-nog cementa (Equia Fil i Ketac Molar Universal). Uzorci tretirani grijanjem polimerizirani su s pomoću polimerizacijske LED svjetiljke Bluephase 16i (Vivadent, Schaan Lihtenštajn), a uzorci bez grijanja ostavljeni su 10 minuta kako bi se kemijski polimerizirali. Prosječna hrapavost površine (*Ra*) izmjeren je profilometrom. **Rezultati:** Rezultati istraživanja pokazali su za oba materijala najniže vrijednosti hrapavosti površine u kontrolnim skupinama s celuloidnom matricom. Pri primjeni materijala Equia Fil uzorci tretirani grijanjem imali su nižu vrijednost prosječne hrapavosti površine (*Ra*) nakon poliranja diskovima Sof-Lex. Za uzorke materijala Ketac Molar Universal su zabilježene statistički značajne razlike (p < 0.05) između onih poliranih volfram-karbidnim svrdlom i diskovima Sof-Lex. **Zaključak:** Na temelju dobivenih rezultata može se zaključiti da najmanju hrapavost površine postiže celuloidnom matricom (engl. *mylar strip*). Grijanjem materijala kod nekih vrsta staklenoionomer-nog cementa može se postići bolja poliranost površine.

**Ključne riječi** staklenoionomerni cementi; površinska svojstva; adhezivnost; grijanje; stomatološko poliranje

**Uvod**
Staklenoionomerne cemente razvili su 1970. godine Wilson i Kent (1). U širokoj su primjeni u kliničkoj praksi zbog niza pozitivnih svojstava – kemijskog vezivanja na tvrda zubna tkiva, otpuštanja fluorida, koeficijenta toplinske ekspanzije sličnih koeficijentu zuba, ne zahtijevaju potpuno suho radno polje, manje su volumetrijske kontrakcije te zadržavaju dubu stabilnost boje (2, 3).

Završavanje restauracije (engl. *finishing*) postupak je definiran kao ukupno oblikovanje ili redukcija morfologije restauracije kako bi se postigla idealna anatomija. Poliranje (engl. *polishing*) smanjenje je površinske hrapavosti i ogrobota nastalih tijekom završnog postupka restauracije (4). Zaostala hrapavost površine može rezultirati upalom gingive, kolo-nizacijom bakterija, povećanom akumulacijom plaka i promjenom boje. Zato su ispravno završavanje i poliranje bitni postupci u restorativnoj stomatologiji jer na taj način povećavamo estetiku i trajnost restauracije (5-7). Površinske ka-

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1 Zavod za dječju i preventivnu stomatologiju Stomatološkog fakulteta Sveučilišta u Zagrebu
2 Privatna stomatološka ordinacija, Hague, Nizozemska

**Staklenoionomerne cemente** razvili su 1970. godine Wilson i Kent (1). U širokoj su primjeni u kliničkoj praksi zbog niza pozitivnih svojstava – kemijskog vezivanja na tvrda zubna tkiva, otpuštanja fluorida, koeficijenta toplinske ekspanzije sličnih koeficijentu zuba, ne zahtijevaju potpuno suho radno polje, manje su volumetrijske kontrakcije te zadržavaju dubu stabilnost boje. Fizička svojstva mogu se poboljšati upotrebom vanjske energije kao što su ultrazvuk i toplina koji ujedno olakšavaju kemijski proces stvarnjanja.

**Svrač**: Željela se usporediti hrapavost površine staklenoionomernih cementa tretiranih grijanjem (engl. *thermo-curing*) i bez grijanja te ustanoviti koja je tehnika poliranja učinkovitija.

**Materijali i metode:** Dva polirajuća sustava (volfram-karbidna svrdla i diskovi Sof-Lex) korištena su za dvije vrste staklenoionomer-nog cementa (Equia Fil i Ketac Molar Universal). Uzorci tretirani grijanjem polimerizirani su s pomoću polimerizacijske LED svjetiljke Bluephase 16i (Vivadent, Schaan Lihtenštajn), a uzorci bez grijanja ostavljeni su 10 minuta kako bi se kemijski polimerizirali. Prosječna hrapavost površine (*Ra*) izmjeren je profilometrom.

**Rezultati:** Rezultati istraživanja pokazali su za oba materijala najniže vrijednosti hrapavosti površine u kontrolnim skupinama s celuloidnom matricom. Pri primjeni materijala Equia Fil, uzorci tretirani grijanjem imali su nižu vrijednost prosječne hrapavosti površine (*Ra*) nakon poliranja diskovima Sof-Lex. Za uzorke materijala Ketac Molar Universal nisu zabilježene statistički značajne razlike (p > 0,05) između onih poliranih volfram-karbidnim svrdlama i diskovima Sof-Lex.

**Zaključak:** Na temelju dobivenih rezultata može se zaključiti da najmanju hrapavost površine postiže celuloidnom matricom (engl. *mylar strip*). Grijanjem materijala kod nekih vrsta staklenoionomer-nog cementa može se postići bolja poliranost površine.

**Sažetak**
Staklenoionomerni cementi često se primjenjuju u kliničkoj praksi zbog niza pozitivnih svojstava – kemijskog vezivanja na tvrda zubna tkiva, otpuštanja fluorida, koeficijenta toplinske ekspanzije sličnih koeficijentu zuba, ne zahtijevaju potpuno suho radno polje, manje su volumetrijske kontrakcije te zadržavaju dubu stabilnost boje. Fizička svojstva mogu se poboljšati upotrebom vanjske energije kao što su ultrazvuk i toplina koji ujedno olakšavaju kemijski proces stvarnjanja. **Svrač**: Željela se usporediti hrapavost površine staklenoionomernih cementa tretiranih grijanjem (engl. *thermo-curing*) i bez grijanja te ustanoviti koja je tehnika poliranja učinkovitija. **Materijali i metode:** Dva polirajuća sustava (volfram-karbidna svrdla i diskovi Sof-Lex) korištena su za dvije vrste staklenoionomer-nog cementa (Equia Fil i Ketac Molar Universal). Uzorci tretirani grijanjem polimerizirani su s pomoću polimerizacijske LED svjetiljke Bluephase 16i (Vivadent, Schaan Lihtenštajn), a uzorci bez grijanja ostavljeni su 10 minuta kako bi se kemijski polimerizirali. Prosječna hrapavost površine (*Ra*) izmjerena je profilometrom. **Rezultati:** Rezultati istraživanja pokazali su za oba materijala najnižu vrijednost hrapavosti površine u kontrolnim skupinama s celuloidnom matricom. Pri primjeni materijala Equia Fil, uzorci tretirani grijanjem imali su nižu vrijednost prosječne hrapavosti površine (*Ra*) nakon poliranja diskovima Sof-Lex. Za uzorke materijala Ketac Molar Universal nisu zabilježene statistički značajne razlike (p > 0,05) između onih poliranih volfram-karbidnim svrdlama i diskovima Sof-Lex. **Zaključak:** Na temelju dobivenih rezultata može se zaključiti da najmanju hrapavost površine postiže celuloidnom matricom (engl. *mylar strip*). Grijanjem materijala kod nekih vrsta staklenoionomer-nog cementa može se postići bolja poliranost površine.

**Ključne riječi**
staklenoionomerni cementi; površinska svojstva; adhezivnost; grijanje; stomatološko poliranje

**Introduction**
Glass Ionomer Cements (GICs) were introduced by Wilson and Kent in 1970 (1). They have been widely used in clinical practice because they possess a wide range of positive characteristics: chemical bonding to the tooth surface, fluoride release, the heat-expansion coefficient similar to the tooth, do not require an absolutely dry working area, less volumetric contraction, good color stability (2, 3).

*Finishing* is defined as shaping of teeth morphology with instruments to achieve ideal anatomy. Polishing eliminates the scratches resulting from finishing instruments and reduces surface roughness (4). Residual surface roughness may result in gingival inflammation, bacterial colonization, increased surface staining and dental plaque accumulation. Finishing and polishing are mandatory steps in restorative dentistry that enhance both longevity of restorations and esthetics (5-7). Surface characteristics and wear resistance of restorations are important criteria to predict the clinical dete-
rhythm for the operation of the material and the durability of the restoration. Poorly polished and rough surfaces contribute to a faster accumulation of dental plaque and bacteria, which increases the gingival inflammation and caries risk. Conversely, a highly polished surface minimizes it and contributes to better esthetics and color stability (8-12).

Several articles have reported that the lowest roughness of GIC surfaces was found after treatment with the Mylar strip. However, the correct morphology of the restoration is rarely achieved by using only the Mylar strip (13-16). Bollen et al. reported that the critical surface roughness (Ra) for bacterial colonization is 0.2 µm. Bacterial accumulation, plaque maturation, and acidification are significantly increased when the surface roughness exceeds 0.2 µm, which affects the material surface, thus increasing caries risk (17). For that reason, finishing and polishing are necessary steps in restorative dentistry that enhance longevity of restorations and esthetics. Additionally, surface roughness can directly affect marginal integrity and the wear behavior of the restoration (18,19).

Surface roughness is micromorphology created by various physical processes used for surface modification. Average roughness (Ra) is the most commonly used parameter to describe surface roughness that is measured with a profilometer. Profilometers provide two-dimensional information, but a scanning electron microscope (SEM) is needed for a complete picture of a detailed analysis. An arithmetic average roughness that can assist clinicians in their treatment decisions can be calculated for each material after polishing treatment (20-24).

The acid-base neutralization reaction of GIC can be accelerated by the use of external energy such as ultrasound (25,26) and heat (27,28). This is particularly useful in overcoming the moisture sensitivity which adversely affects the properties of GIC material (29-31). Although ultrasound accelerated the setting, its use was clinically difficult. On the other hand, heat can be applied through portable LED lamps. Commercial Glass Ionomer Cements are now available on the market with manufacturer’s instructions for applying thermo-curing technique using radiant heat from portable LED lamps (32). There was a concern that such heat exposure could have a potentially harmful effect on the dental pulp. Based on the obtained results of Van Duijnen et al., it could be concluded that the use of external heat during the setting of GIC material does not lead to harmful overheating of the pulp tissue; hence it does not cause any pathological conditions. On the contrary, for improving the adhesion of GIC material and mechanical properties, the application of external heat (thermo-curing) as a “Command set” method could be part of regular clinical practice (3).

The aim of this study was to analyze the effect of polishing instruments on surface roughness of GIC and to determine the differences in the quality of polishing of GIC treated with heat (thermo-curing) and without the application of heat treatment. The null hypothesis was that GIC treated with heat (thermo-curing) obtain the lower surface roughness value.
Materijali i metode

U istraživanju su korištene dvije vrste staklenoionomernog cementa – Equia Fil (GC korp., Tokio, Japan) i Ketac Molar Universal (3M ESPE, Seefeld, Njemačka). Svaka vrsta podijeljena je u tri skupine – onu tretiranu grijanjem, bez tretmanu grijanjem i kontrolnu (tablica 1.).

Ukupno 60 uzoraka (10 iz svake skupine) pripremljeno je u standardiziranim gumenim kalupima dimenzije 2 x 2 x 10 mm te podijeljeno u 6 skupina. Svaki uzorak staklenoionomernog cementa strojno je zamiješan prema uputama proizvođača i podijeljen u četiri gradacije diskova (srednji, fini, i ultra-fini) i tri gradacije volframa-karbida (vrstajna) pri intenzitetu od 1600 mW/cm². Tijekom grijanja vršila se standardizacija unutar skupine.

Nakon sedam dana uzorci su izvaženi te očišćeni alkoholskiom medijom, fine, i ultra-fine) i tri gradacije volfram-karbidnim svrdlima (Komet Dental, Brasseler GmbH & Co KG) (tablica 2.).

Svaki uzorak poliran je prema uputama proizvođača kad je riječ o brzini rotacije svrdala i vremenu aplikacije polirajućeg sredstva. Osim kontrolnih skupina, polovina uzoraka iz svake skupine tretirana je grijanjem (thermo-curing). Uzorci polirani u standardiziranih gumenih kalupima (Mylar strip) pri intenzitetu od 1600 mW/cm². Tijekom grijanja vršila se standardizacija unutar skupine.

Osim kontrolnih skupina, polovina uzoraka iz svake skupine tretirana je grijanjem. Korištene su četiri gradacije diskova (grubi, srednji, fini, i ultra-fine) i tri gradacije volfram-karbidnim svrdlima (Komet Dental, Brasseler GmbH & Co KG) (tablica 2.).

U istraživanju su korištene dvije vrste staklenoionomernog cementa – Equia Fil (GC korp., Tokio, Japan) i Ketac Molar Universal (3M ESPE, Seefeld, Njemačka). Svaka vrsta podijeljena je u tri skupine – onu tretiranu grijanjem, bez tretmanu grijanjem i kontrolnu (tablica 1.).

Material and methods

Two types of GIC were used in this study, Equia Fil (GC Corp, Tokyo, Japan) and Ketac Molar Universal (3M ESPE, Seefeld, Germany). The specimens of each material were divided into three groups: treated with heat (thermo-curing) without heat and the control group (Table 1).

All 60 specimens were prepared using standardized rubber molds with dimensions 2x2x10mm and divided into six groups (n=10). Material for each sample was capsulated and mechanically mixed according to the manufacturer's instructions and inserted into the molds using a hand applicator for the capsules. The material was covered with a transparent Mylar strip on the top of the filled mold. A glass plate was placed against the top surface of the transparent Mylar strip and pressed with light pressure to expel the excess material from the mold. Bluephase 16i LED light (Vivadent, Schaan Liechtenstein) was used at an intensity of 1600 mW/cm² for the GIC specimens treated with heat (thermo-curing). The samples without heat treatment were left for 10 minutes to chemically cure. During heating, the tip of the polymerization device was in contact with the Mylar strip to standardize the distance between the heat source and the sample on the thickness of the Mylar strip. The samples treated by thermocuring were treated for 60 seconds in three places for 20 seconds each (in the middle and at the ends of molds) so that all parts of the cement were equally affected. Subsequently, the prepared samples were stored in a petroleum jelly as a storage media for a week.

After seven days, the samples were cleaned with alcohol. Apart from control group, half of the samples of each experimental group, were polished with Sof-Lex discs system with water cooling (3M ESPE, St. Paul, USA), and the other half with Tungsten carbide drills (Komet Dental, Brasseler GmbH & Co KG) (Table 2.).

Each sample was polished according to the manufacturer’s instructions with respect to the speed of rotation of the spindle and the application time of the polishing agent. In order for the samples to have a smooth surface, the polishing was performed evenly and flatly from the left to the right direction. All samples were made by the same operator to eliminate individual operator differences and made equal pressure on the GIC samples. Four grades of Sof-Lex discs (rough, medium, fine, and ultra-fine) and three graduations of Tung-
skupine nisu polirane. Polovica svake kontrolne skupine tre-
tirana je grijanjem, a druga polovica nije.

Prije mjerenja hrapavosti površine (Ra), svi uzorci su osu-
šeni. Hrapavost površine (Ra) izmjerena je profilometrom
(KairDa, Kina) (slika 1.). Svaki uzorak izmjeren je na pet ra-
zličitih mjesta te je uzeta prosječna vrijednost dobivenih re-
zultata. Svi rezultati podvrgnuti su statističkoj analizi. Ko-
rirište metode statističke analize bile su ANOVA (analiza
varijance -analysis of variance) i Tukeyjev HSD test uz razinu
značajnosti od 5 % (p < 0,05).

Rezultati
Na uzorcima staklenoionomernog cementa Ketac Molar
Universal najmanja hrapavost površine izmjerena je u kon-
trolnoj skupini s celuloidnom matricom (eksperimentalna
skupina 5). U kontrolnoj skupini nije bilo statistički značajne
razlike (p < 0,05) između uzoraka tretiranih grijanjem i onih
bez tretmana grijanjem. Rezultati dobiveni za eksperimental-
ne skupine 1 i 2 nakon poliranja uzoraka diskovima Sof-Lex
i volfram-karbidnim svrdlima, u usporedbi tih dvaju polirnih
sredstava, nisu pokazali statistički značajnu razliku (p > 0,05).
Dakle, rezultati pokazuju da nema značajne razlike u odabi-
ru između tih dvaju polirnih sredstava za tu vrstu staklenoio-
nomernog cementa. Usporedba uzoraka poliranih diskovima
Sof-Lex tretiranim grijanjem i uzoraka poliranih diskovima
Sof-Lex bez grijanja, pokazuju manju hrapavost uzoraka tre-
sten carbide drills (blue, yellow and white) were used. After
the completed polishing process, the samples were stored for
24 hours in distilled water. The control groups were not pol-
ished. Half of each control group was treated by thermo-cur-
ing and the other half without thermo-curing.

Prior to surface roughness measurement (Ra), all samples
were dried. The surface roughness (Ra) was measured by a
profilometer (KairDa, China) (Figure 1). Each sample was
measured in five different places and the average value of the
obtained results was taken. The obtained results were subject-
ed to statistical analysis. The statistical analysis methods used
were the analysis of variance (ANOVA) and the Tukey HSD test
at a level of 95% significance (p <0.05).

Results
The specimens of GIC Ketac Molar Universal obtained
smallest surface roughness in the control group with the
Mylar strip (experimental group 5). There were no statisti-
cally significant differences (p <0.05) between the samples
treated with a heat (thermo-curing) and samples without heat-
ing treatment within the control groups. The results obtained
for the experimental groups 1 and 2 after polishing the sam-
ple with Sof-lex discs system and Tungsten carbide drills
did not show a statistically significant difference (p> 0.05) in
the mutual comparison of these two polishing agents. Thus,
the results indicate that there were no significant differenc-
es in the choice between these two polishing agents for this
type of GIC. A comparison of samples polished with Sof-lex
disks with thermo-curing and without thermo-curing showed
tiranih bez grijanja. Rezultati dobiveni testiranjem uzoraka poliranih volfram-karbidskim svrđima tretiranih grijanjem i uzoraka bez grijanja nisu pokazali statistički značajnu razliku (p > 0,05) (tablica 3).

Uzorci staklenoionomernog cementa Equa Fil imali su najmanju hrapanost površine u kontrolnoj grupi s celuloidnom matricom (ekспериментална skupina 6). U kontrolnoj skupini nije bilo statistički značajne razlike (p > 0,05) između uzoraka tretiranih grijanjem i onih bez tretmana grijanjem. U eksperimentalnim skupinama 3 i 4 uzorci polirani diskovima Sof-Lex ostvarili su bolje rezultate u odnosu prema uzor-cima tretiranim bez grijanja. Rezultati dobiveni testiranjem uzoraka poliranih volfram-karbidskim svrđima tretiranih grijanjem i uzoraka bez grijanja nisu pokazali statistički značajnu razliku (p > 0,05) (tablica 3).

The specimens of GIC Equa Fil obtained the smoothest surface roughness in the control group with the Mylar strip (experimental group 6). Within the control groups, there were no statistically significant differences (p < 0,05) between the samples treated with thermo-curing and the samples without thermo-curing. In the experimental groups 3 and 4, the lower roughness values than the samples treated without thermo-curing. The results obtained by testing samples of polished Tungsten carbide drills treated with thermo-curing and non-heating samples showed no statistically significant differences (p > 0,05) (Table 3).

| Materijal • Material | Poliranje • Polishing instrument | N | Ra     | Std.Dev | min   | max   |
|----------------------|----------------------------------|---|--------|---------|-------|-------|
| Ketac Molar U. bez grijanja • without heating | volfram-karb. • Tung-carb | 10 | 0,727800 | 0,138397 | 0,563000 | 0,992000 |
|                      | Sof-Lex                          | 10 | 0,629609 | 0,162293 | 0,372000 | 0,851000 |
|                      | cel. mat. • Mylar                | 10 | 0,277200 | 0,021091 | 0,244000 | 0,308000 |
| Ketac Molar U. + grijanje • with heating | volfram-karb. • Tung-carb | 10 | 0,779300 | 0,086857 | 0,643000 | 0,988000 |
|                      | Sof-Lex                          | 10 | 0,795280 | 0,190414 | 0,606000 | 1,129000 |
|                      | cel. mat. • Mylar                | 10 | 0,342100 | 0,054803 | 0,287000 | 0,399000 |

**Tablica 4.** Prosjecna hrapanost površine (Ra) za staklenoionomerni cement Equa Fil Average surface roughness (Ra) for Equa Fil Cement

| Materijal • Material | Poliranje • Polishing instrument | N | Ra     | Std.Dev | min   | max   |
|----------------------|----------------------------------|---|--------|---------|-------|-------|
| Equa Fil – bez grijanja • without heating | volfram-karb. • Tung-carb | 10 | 1,070320 | 0,175747 | 0,717000 | 1,332000 |
|                      | Sof-Lex                          | 10 | 0,767240 | 0,241597 | 0,469000 | 1,206000 |
|                      | cel. mat. • Mylar                | 10 | 0,233400 | 0,010499 | 0,215000 | 0,246000 |
| Equa Fil + grijanje • with heating | volfram-karb. • Tung-carb | 10 | 0,886480 | 0,045677 | 0,812000 | 0,967000 |
|                      | Sof-Lex                          | 10 | 0,694400 | 0,125892 | 0,441000 | 0,849000 |
|                      | cel. mat. • Mylar                | 10 | 0,344000 | 0,023132 | 0,312000 | 0,378000 |

**Tablica 5.** Analiza varijance (ANOVA) prosječne površinske hrapanosti (Ra) GIC sa i bez grijanja nakon poliranja tungsten karbidnim brusilima i Sof-Lex diskovima

**Tablica 6.** Tukey HSD post hoc test prosječne površinske hrapanosti (Ra) GIC sa i bez grijanja nakon poliranja tungsten karbidnim brusilima i Sof-Lex diskovima

**Table 5** ANOVA of the surface roughness (Ra) of GIC materials with and without heating treatment after polishing with Tungsten carbide drills and Sof-Lex discs.

**Table 6** Tukey HSD post hoc test of the surface roughness (Ra) of GIC materials with and without heating treatment after polishing with Tungsten carbide drills and Sof-Lex discs.
cima poliranima volfram-karbidnim svrdlima. U usporedbi uzoraka poliranih volfram-karbidnim svrdlima manja hrapa-
vost površine (Ra = 0.88) postignuta je u uszoricama tretirani-
gi grijanjem u odnosu prema onima poliranima volfram-
karbidnim svrdlima bez grijanja (Ra = 1.07). Uzorci obrađeni
diskovima Sof-Lex koji su tretirani grijanjem ostvarili su nižu
prosječnu hrapavost Ra (Ra = 0.69) u odnosu prema uzorci-
ma bez grijanja (Ra = 0.76), iako ustanovljena razlika nije bila
statistički značajna (p > 0.05) (tabl. 4., 5. i 6.).

Grafički prikaz prosječne hrapavosti površine (Ra) na-
kon obrade SIC materijala Sof-Lexovim sustavom diskova, volfram-karbidnim bušilicama i celuloidnom matricom (sli-
ka 2.).

Rasprava

Staklenioionomerni cementi u širokoj su upotrebi u den-
talnoj medicini, posebno u pedodocnici zbog mnoštva dobrih
svojstava. No slabija mehanička svojstva i smanjena otpor-
nost na trošenje vrstaju staklenioionomerne restauracije u
manje trajne (32). Hrapavost površine SIC-ovih restaurativ-
ih materijala ima nekoliko kliničkih implikacija i promje-
da na površinskoj morfologiji te je često određena kao mjera
za trošenje/habanje materijala. Povećana hrapavost može bi-
ti predisponirajući čimbenik za mikrobnu kolonizaciju ko-
ja može povećati rizik od oralnih bolesti. Povećana hrapavost
površine može također uzrokovati pogošanje materijala (9,
33).

Bollen i suradnici odredili su graniču vrijednost hrapa-
vosti površine (Ra) većine dentalnih materijala za bakterij-
sku kolonizaciju koja iznosi 0.2 μm. Vrijednosti više od 0.2
μm sklonije su povećanoj adheziji dentalnog plaka i bakteri-
ja, što se na površinu materijala odražava kao povećani rizik
od karijesa (17). No staklenioionomerni cementi to djelomič-
no kompenziraju jer djeluju antikarijesno otpuštanju fluo-
rida koji se ugrađuju u rešetku hidroksiapatita te usporava-
ju procese demineralizacije i pridonose remineralizaciji (11,
17, 34). S kliničkog stajališta, povećana hrpaovost površine
može također uzrokovati pogošanje materijala (9, 33).

Rastaklenioionomerni cementi u širokoj upotrebi u den-
talnoj medicini, posebno u pedodocnici zbog mnoštva dobrih
svojstava. No slabija mehanička svojstva i smanjena otpor-
nost na trošenje vrstaju staklenioionomerne restauracije u
manje trajne (32). Hrapavost površine SIC-ovih restaurativ-
ih materijala ima nekoliko kliničkih implikacija i promje-
da na površinskoj morfologiji te je često određena kao mjera
za trošenje/habanje materijala. Povećana hrapavost može bi-
ti predisponirajući čimbenik za mikrobnu kolonizaciju ko-
ja može povećati rizik od oralnih bolesti. Povećana hrapavost
površine može također uzrokovati pogošanje materijala (9,
33).

Bollen i suradnici odredili su graniču vrijednost hrapa-
vosti površine (Ra) većine dentalnih materijala za bakterij-
sku kolonizaciju koja iznosi 0.2 μm. Vrijednosti više od 0.2
μm sklonije su povećanoj adheziji dentalnog plaka i bakteri-
ja, što se na površinu materijala odražava kao povećani rizik
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Rezultate slične ovima u našem istraživanju istaknuto je
i nekoliko autora u svojim studijama u kojima je ustanovljeno
no da najmanju hrapavost imaju površine staklenionomernog
cementa nakon tretiranja celuloidnom matricom (engl.
mylar strip). No pravilna anatomija i morfologija ispuna rijet-
ko se postiže samo korištenjem celuloidne matrice (36 – 37).
U ovom istraživanju korišteni su diskovi Sof-Lex i volfram-
karbidna svrdla. Kad je riječ o Ketac Molar Universalu, nije
bilo statistički značajne razlike (p > 0.05) između tih dvaju
polirnih sredstava, a za Equia Fil dobiveni su bolji rezultati za
uzorke tretirane diskovima Sof-Lex. Rezultati potiču na raz-
išljanje – može li uspješnost poliranja ovisiti i o vrsti resta-

the samples polished with Sof-lex discs system yielded better
results compared to samples polished with the Tungsten car-
bide drills. In the comparison of the samples polished with
Tungsten carbide drills, the smoothest surface roughness (Ra
= 0.88) was achieved with thermo-curing treatment samples
compared to polished Tungsten carbide drills without ther-
mo-curing treatment (Ra = 1.07). The samples polished with
Sof-lex discs system treated with thermo-curing achieved a
lower average roughness Ra (Ra = 0.69) compared to non-
heated samples (Ra = 0.76), although the observed difference
was not statistically significant (p > 0) (Table 4, 5 and 6).

Graphic presentation of average surface roughness (Ra)
after treatment of GIC materials with Sof-Lex discs system;
Tungsten carbide drills and with Mylar strips (Figure 2).

Discussion

Glass-ionomer cements (GICs) have been widely used in
dental medicine, especially in pediatric dentistry due to a
large number of good features. However, lower mechan-
ic properties and reduced wear resistance put a GIC resto-
ration into less durable restorations (32). Surface roughness
of GIC materials has several clinical implications and chang-
es in surface often defined as a measure of wear of materials.
An increased roughness can be a predisposing factor for bac-
terial colonization that increases the risk of oral disease. Also,
increased roughness of the surface can cause deterioration of
the material (9, 33).

Bollen et al. reported that critical surface roughness (Ra)
for bacterial colonization is 0.2 μm. Bacterial accumulation,
plaque maturation and acidity significantly increase when
the surface roughness exceeds 0.2 μm, which acts on mate-
rial surfaces, thus increasing caries risk (17). However, GICs
partially compensate for their anti-caries release of fluoride
that is incorporated into the hydroxyapatite lattice and slow
down the processes of demineralization and contribute to the
remineralization process (11, 17, 34). From a clinical point
of view, the increased surface roughness of the restored tooth
surface causes accumulation of plaque, secondary caries, gin-
givitis and loss of periodontal attachment, and ultimately re-
storat ion loses its shine and color (35). One of the flaws of to-
day’s GIC is worse polishing properties than composites, but
newer GICs are increasingly approaching the quality of pol-
ishing composite materials.

Several authors in their studies showed the results simi-
lar to this study that the lowest surface roughness of GICs
materials was found in the surface in contact with the Mylar
strip. However, a correct anatomy and morphology of filling
is rarely achieved only by using the Mylar strip (36, 37). Sof-
Lex disks system and Tungsten carbide drills were used in this
study. Ketac Molar Universal did not show statistically signifi-
cant differences (p > 0.05) between these two polishing agents,
but Equia Fil material showed better results in samples treat-
ed with Sof-Lex disks. The results suggest that polishing per-
formance may also depend on the type of restorative material
and the particle size, as confirmed by Bala et al. (38).

Poor mechanical properties and reduced wear resistance
to GICs materials represent a sort of clinical problem. How-


Staklenoionomerni cementi nakon poliranja

Miličević i sur.

Zaključak
Na temelju dobivenih rezultata može se zaključiti da najmanju hravost površine postižemo celuloidnom matricom.

Nulta hipoteza ovog istraživanja nije u cijelosti potvrđena za to što je dio uzoraka postigao manju hravost površine nakon tretiranja grijanjem u skladu s pretpostavkom nulte hipoteze, a dio veću u odnosu prema uzorcima bez grijanja. Primjenom tretmana grijanjem materijala za neke vrste staklenoionomernih cemenata može se postići bolja poliranost površine.

Sukob interesa

Authors nisu bili u sukobu interesa.

Conclusions

Based on the obtained results it can be concluded that the smoothest surface roughness is achieved by the Mylar strip.

The null hypothesis of this study was not fully validated because part of the samples obtained less surface roughness after they had been treated by thermo-curing according to the assumption of the null hypothesis, and the part of them achieved greater surface roughness compared to the samples without heating. Some types of GICs can obtain better surface polishing with heat treatment of the material (thermo-curing).

Conflict of interest

None declared.

Glass Ionomer Cements (GIC) have been widely used in clinical practice since they have a wide range of positive characteristics: chemical bonding to the tooth surface, fluoride release, a heat-expansion coefficient similar to the tooth, do not require an absolutely dry working area, less volumetric contraction, good color stability. Physical properties can be improved by using external energy such as ultrasound and radiant heat (thermo-curing), which also accelerates chemical curing. Objectives: The aim of this study was to determine the most effective polishing technique and to compare the surface roughness of two Glass Ionomer Cements after treatment with heat (thermo-curing), and without heat treatment during the setting process. Materials and methods: Two polishing systems (Tungsten carbide burs and Sof-Lex discs) were used on two types of GIC (Equia Fil and Ketac Molar Universal). Bluephase 161 LED (Vivadent, Schaan Liechtenstein) light was used for the specimens treated with heat (thermo-curing). Samples without heat treatment are left for 10 minutes to chemically cure. Surface profilometer was used for measuring the mean surface roughness value (Ra). Results: Group with Mylar strip (control group) of each material showed the lowest (Ra) value. The Equia Fil material samples treated with heat (thermo-curing) achieved lower surface roughness values (Ra), and showed lower surface roughness values (Ra) after polishing with a Sof-Lex discs (p<0.05). The results for Ketac Molar Universal samples showed no statistically significant difference (p>0.05) between polishing with Sof-Lex discs and Tungsten carbide burs. Conclusion: Based on the obtained results, it can be concluded that the smoothest surface roughness is achieved by the Mylar strip. Some types of Glass Ionomer Cements can obtain better surface polishing with heat treatment (thermo-curing).

Key words
Glass Ionomer Cements; Surface Properties; Adhesiveness; Heating; Dental Polishing
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