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IZVORNI ZNANSTVENI RAD
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Učinak električnih četkica na trošenje dentina

Influence of Powered Toothbrushes on Dentine Wear

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Sažetak
Svrha: Svrha rada bila je odrediti stupanj trošenja dentina nakon što se zubi četkaju električnom četkicom s glavama različitih veličina te primijene različita opterećenja u usporedbi s običnom (mehaničkom) četkicom za zube. **Materijal i postupci:** Za to su odabrane električne četkice Sonicare-Elite s malom i standardnom veličinom glave i vertikalnim opterećenjem od 90 i 150 grama te mehanička četkica Oral-B-P35 s vertikalnim opterećenjem od 150 grama. Ona je istodobno služila i kao kontrolna. Uređajem za simulaciju četkanja s različitim brojem okretaja koristili smo se kako bismo postigli abraziju dentina četkanjem. Za standardne veličine glave Sonicare-Elite rabilo se 12 000 okretaja, a za mini glavu 18 000. Za četkicu Oral-B-P35 izabrali smo 12 500 okretaja. Laserskim scannerom 3D koristili smo se za evaluacije trošenja dentina. **Rezultati:** Rezultati su pokazali da je najveće trošenje dentina bilo kod uporabe manualne četkice (107,26μm), a najmanje kod četkice Sonicare-Elite sa standardnom veličinom glave i 90 grama vertikalnog opterećenja (47.7μm). Nisu potvrđene statistički znatne razlike izmedju električne četkice s "mini" glavom (90 grama opterećenja) i standardnom veličinom glave (90 i 150 grama opterećenja) te električne četkice s "mini" glavom i opterećenjem od 150 grama i manualne četkice. **Zaključak:** Električne četkice s različitim veličinama glave i različitim vertikalnim opterećenjima različito troše dentin i što je manja glava te jače opterećenje, to je veće trošenje dentina.

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Ključne riječi
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Uvod

Četkanje zuba osnova je profilakse i oralne higijene. Iako je mnogo pozitivnih učinaka kod četkanja zuba, ako je ono nepravilno zna se da može nepovoljno utjecati na gingivu i tvrdo zubno tkivo. Najčešće posljedice su recesija gingive s ogoljenjem korijena te cervikalna abrazija cementa i dentina, pa nastaje dentinska preosjetljivost, ali i estetski problemi (1).

Introduction

Toothbrushing is the most common means of oral prophylaxis and hygiene. Despite its positive effect, it has been known that toothbrushing can have some unwanted effects on the gingival and hard tooth tissue. Gingival recession with root surface exposure and cervical abrasion of cementum and dentin, are the most prevalent consequences of inappropriate toothbrushing, and can cause great discomfort for patients, dentine hypersensitivity and aesthetic problems (1).

Trošenje zuba zbog abrazije rezultat je zajedničkog učinka abraziva primijenjenog pritiska te karakteristika četkice (2). Znanstveni rezultati pokazuju da je caklina rezistentna na abraziju kod većine zubnih pasta. Suprotno tome, dentin je podložniji abraziji od cakline ako se rabi zubna pasta, pa državni i međunarodni standardi postavljaju abrazijski limit primarno određen prema testiranjima provedenima na dentinu (3).

Električne četkice za zube prvi su put bile predstavljene ranih šezdesetih godina kada se zaključilo da mogu poboljšati oralnu higijenu. Od tada se često raspravljalo o tome jesu li i koliko bolje od standardnih manualnih (4). Godine 1964. Ash (5) je zaključio da su mnogo važnije pravilne upute kako treba četkati zube, negoli izbor i oblik četkice.

Bilo je i mnogo kliničkih ispitivanja kako bi se usporedila učinkovitost električne četkice i one manualne, no rezultati i mišljenja bili su suprotni. Na početku je u nekoliko studija bilo istaknuto zašto su električne četkice lošije u odnosu prema manualnima, dok je u ostalima jasno pokazana superiornost električnih u odnosu prema manualnima - kako za kontrolu i uklanjanje plaka, tako i za poboljšanje gingivnog zdravlja općenito (6,7,8).

Za procjenu dentinske abrazije uzrokovane zubnim pastama i njihovim sastavima primjenjivali su se i procjenjivali različiti materijali i postupci, no nažalost nema dovoljno podataka o abraziji nakon četkanja bez utjecaja paste. Četkanje zuba pastom uklanja zaostali sloj i eksponira dentinske tubuluse (9). Moore i Addy (10) dokazali su u svojoj studiji da se uporabom takvog četkanja ne uklanja samo zaostatni sloj nego i dentin. Četkanje bez paste uklanja samo zaostatni sloj debljine 1 μm (11). Objašnjenje za to jest rezultat ispitivanja spomenutih autora, no oni nisu dokazali znatno trošenje dentina tijekom četkanja vodom kod 20 000 okretaja u usporedbi s 10 000 okretaja (10).

Električne četkice za zube danas se smatraju znatno učinkovitijima nego manualne. Tehnološki razvoj omogućio je tzv. zvučne četkice s visokom frekvencijom od približno 30 000 okretaja u minuti. No, u nekim se studijama ističe da veći broj okretaja ne utječe znatno na oštećenje tvrdoga zubnog tkiva ili restoraciju zbog kompenzirajućeg učinka takvih električnih četkica te da njihova uporaba u uvjetima in vivo može završiti manjim abrazijama, što se ne događa kod standardne manualne tehnike četkanja (12,13).

Svrha rada bila je ispitati kako se troši tvrdo zubno tkivo, točnije dentin tijekom uporabe električne

Wear due to the abrasion is a function of: the type of abrasive, the pressure applied and the stiffness or texture of the bristles (2). Laboratory data indicates that enamel is resistant to abrasion by most toothpastes. On the contrary, dentine appears more susceptible to toothpaste abrasion than enamel, and national and international standards set toothpaste abrasivity limits based primarily on tests of abrasion on dentine (3).

The electric toothbrush was first introduced in the early 1960s when it was considered to have the potential to significantly improve the standard of oral hygiene in the general population. Since that time, there has been much controversy as to whether the electric toothbrush really is more effective than a conventional toothbrush (4). In 1964 Ash concluded that professional dental care and instruction of the patient in how to brush correctly was more important than toothbrush design (5).

Clinical studies designed to compare the efficacy of electric toothbrushing with that of manual toothbrushing have lead to conflicting results and opinions. In the past, several studies have failed to show any benefit of an electric toothrush over the use of a conventional manual toothbrush, whilst others have clearly demonstrated the electric toothbrush to be superior in terms of both plaque removal and improvement in gingival health (6,7,8) .

A variety of methods and materials have been used to study and measure dental abrasion by toothpaste and their ingredients, but unfortunately there is not enough information about dentine abrasion caused by toothbrushing without influence of dentifrice. Brushing teeth with toothpaste removes the smear layer and exposes the underlying dentin tubules (9). Moore and Addy (10) show in their study that not only the smear layer is removed but also body dentine. The water brushing appeared to only remove the smear layer, which is quoted as 1 μm thick (11). Evidence for this is the experiment from the same authors which shows lack of significant increase in dentin loss with waterbrushing at 20000 strokes compared to 10000 strokes (10).

One approach in powered toothbrush technology has been the development of sonic toothbrushes that have a high frequency of filament movement in excess of approximately 30000 strokes per minute. However, it has been concluded that an increase in the number of brushing strokes was not necessarily damaging to hard dental tissue or several types of restorative materials. This is because of other compensating factors of powered toothbrushes, and the

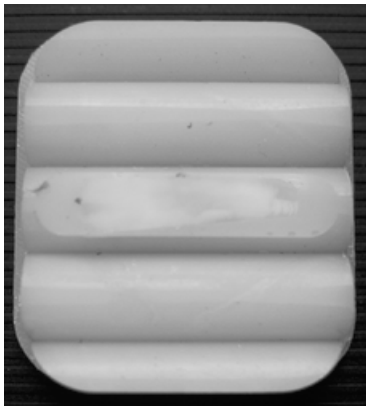
četkice Sonicare-Elite s dvjema različitim veličinama glave i standardne manualne četkice, uz primjenu različitog opterećenja.

Materijali i postupci

Priprema uzoraka

Za pripremu dentinskih uzoraka rabljeni su ekstrahirani, potpuno intaktni zubi čuvani u fiziološkoj otopini s antimikrobnim sredstvom N_3Na.

Zubi su bili razrezani standardnom dijamantnom pilom (Isomet, Buehler) i dijamantnim nožem s niskim brojem okretaja u incizalno-apikalnom smjeru, kako bi se dobili uzorci debljine 2 mm, širine 3 mm te dužine 10 mm. Pritom su se nastojali izbjeći rogovi pulpe, njezina komorica i kanali. Dodatno su svi izabrani i tako pripremljeni uzorci pregledani optičkim mikroskopom kako bi se isključile sve nepravilnosti, kao što su diskoloracije ili drugi znakovi sklerotičnog dentina. Nakon preparacije i izbora reprezentativnih uzoraka dentina, uzorci su uloženi u model od samostvrdnjavajućeg materijala za izradu provizorija (Luxatemp, DMG, Hamburg, Njemačka). Model s dentinskim uzorkom bio je napravljen tako da simulira oblik zuba u zubnom luku (Slika 1.). Površina uzoraka ispolirana je papirom SiC finoće 400, 600 i 1200. S iznimkom fisura i kvržica, dentinska je površina zaravnata s površinom modela nakon obrade površine. Težina uzoraka kontrolirala se i prilagođavala prije svakog mjerenja elektroničkom vagom. Unaprijed pripremljeni uzorci nasumce su se birali i odvajali za eksperimentalne skupine. Čuvali su se u plastičnim vrećicama omotani u vlažnu gazu, kako bi se spriječila dehidracija.



Slika 1. Dentinski uzorak uložen u akrilatni blok
Figure 1 Dentine sample embedded into a model made from a self-curing material

use of such devices in vivo may produce less abrasion than usual manual brushing methods (12,13).

This in-vitro study examines hard tooth surface wear resulting from the use of an oral hygiene device in a controlled oral condition. Specifically, this protocol compares dentin wear associated with the use of: manual toothbrush and Sonicare Elite with two different brush heads in accordance with the usual usage conditions.

Materials and Methods

Specimen preparation

Extracted teeth stored in physiologic saline solution with the antimicrobial agent sodium azide (N_3Na) were used as a dentin source. Only the teeth without caries or restorations in the plane of the section were chosen for this experiment.

The teeth were sectioned with a slow speed diamond saw with a diamond-wafering blade cooled with water bath along the inciso-apical plane to obtain 2 mm thick dentin slices, that were 3 mm wide and 10 mm long. The pulp canals or pulp chambers were to be avoided. Additionally, all the chosen dentin samples were optically checked and all samples which exhibited any irregularities like discolorations or other sign of sclerotic dentin, were eliminated. After properly preparing and choosing dentin slices, the selected slices were embedded into a model made from a self-curing material for temporary crown and bridge (C&B) restorations (Luxatemp, DMG, Hamburg, Germany) (Figure 1). The surface of the specimen was sanded and finished using a 400 grit, 600 grit and finally a 1200 grit SiC-paper. With the exception of the valleys between the ridges, the dentin surface was co-planed to the model surface after the surface treatment. The weight of the samples was controlled and adjusted before each test with an electronic balance. The dentin slices were prepared in advance and assigned randomly to the experimental groups. They were stored in plastic bags wrapped in wet tissues to keep the samples hydrated prior to testing.

Ispitivale su se sljedeće četkice za zube uz primjenu različitog vertikalnog opterećenja:

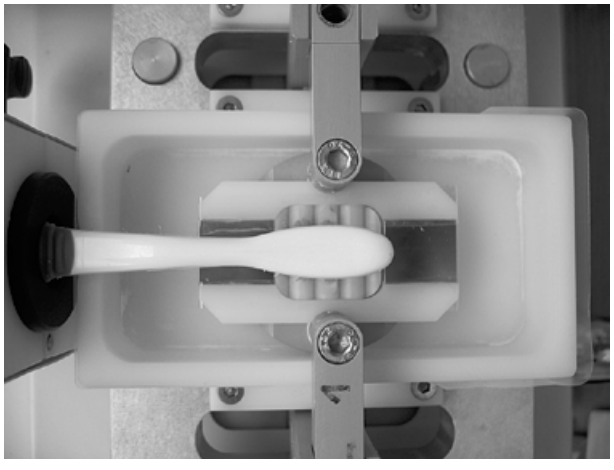
1. Sonicare-Elite e7000 (glava HX7001, držak HX7001, Philips, Washington, SAD) sa standardnom veličinom glave te vertikalnim opterećenjem od 90 grama i 12 000 okretaja;
2. Sonicare-Elite e7000 električna četkica sa standardnom veličinom glave te vertikalnim opterećenjem od 150 grama i 12 000 okretaja;
3. Sonicare-Elite e9000 (glava HX7011, držak HX7001, Philips, Washington, SAD) električna četkica s "mini" glavom te vertikalnim opterećenjem od 90 grama i 18 000 okretaja;
4. Sonicare-Elite e9000 električna četkica s "mini" glavom te vertikalnim opterećenjem od 150 grama i 18 000 okretaja;
5. Oral-B P35 (Iowa City, IA, SAD) manualna četkica s vertikalnim opterećenjem od 150 grama te 12 500 okretaja (kontrolna skupina).

Ukupno je bilo pripremljeno 60 uzoraka - 12 za svaku skupinu.

Simulacija četkanja

Uzorci su bili postavljeni u uređaj za simulaciju četkanja tako da je glava četkice bila potpuno u doticaju s dentinom (Slika 2.). Električne su četkice bile priključene na vanjski izvor energije, kako bi se tijekom pokusa osigurali konstantni uvjeti. Glava četkice mijenjala se prije svakog testa, tako da je svaki uzorak imao četkicu s novom glavom.

Uređaj za četkanje ima šest mjesta za montiranje četkica. Zbog prirode pokreta i ovisnosti o veličini glave, u uređaju se ispitivala isključivo jedna po jedna vrsta četkice. Uzorci su bili postavljeni ispod glave četkice za zube, tako da je uzorak bio paralelan s ravninom koju čine vlakna četkice te je srednji dio glave četkice prolazio preko sredine promatranog područja. Kako bi se simulirale sile četkanja,



Slika 2. Četkica montirana u uređaj za simulaciju četkanja
Figure 2 Toothbrush machine with mounted toothbrush

The following toothbrushes with different vertical loads were compared:

1. Sonicare Elite e7000 (head HX7001, handle type HX7001, Philips, Washington, USA) powered toothbrush with standard sized brush head at 90 g vertical load; 12000 strokes
2. Sonicare Elite e7000 powered toothbrush with standard sized brush head at 150 g vertical load; 12000 strokes
3. Sonicare Elite e9000 (head HX7011, handle type HX7001, Philips, Washington, USA) powered toothbrush with mini sized brush head at 90 g vertical load; 18000 strokes
4. Sonicare Elite e9000 powered toothbrush with mini sized brush head at 150 g vertical load; 18000 strokes
5. Oral-B P35 (Iowa City, IA, USA) manual toothbrush at 150 g vertical load; 12500 strokes (control).

A total of 60 samples were made, 12 samples for each group.

Simulated brushing

The samples were mounted in the toothbrush machine and aligned so that the brush head was in proper contact with the dentin and the center of the brush head passed over the dentin surface (Figure 2). The powered toothbrushes were externally powered to guarantee constant conditions throughout the test. The brush heads were replaced before each test so that each specimen had a new brush head.

Due to the nature of the motion and its dependency on the brush size, only one type of device (treatment) was tested in the brushing machine at a time. The brushing machine has six stations for devices of the same type. The specimens were mounted below the six toothbrush heads in such a way that the specimen sample was at the same level with respect to the toothbrush filament tip plane. The specimen was oriented so that the center of the brush head passed over the center of the region of interest (ROI). Weight was added to simulate the brushing force as required for each brush group. The sample holder was designed to be long so that the toothbrush head was fully supported throughout the entire brushing cycle.

dodana je težina za svaku ispitivanu skupinu. Držač uzoraka bio je napravljen tako da je glava četkice u cijelosti bila poduprta, odnosno prekrivala je uzorak tijekom cijelog ciklusa četkanja. Konstantna aplituda četkanja od 43 mm bila je odredjena na temelju najveće glave četkice, kako bi se osigurala ista ekspozicija dentinskog uzorka za sve vrste ispitivanih četkica. Trajanje ekspozicije dentinskog uzorka bilo je odredjeno prema veličini glave četkice. Kako bi se simulirali klinički relevantni uvjeti četkanja, rabljena su tri različita broja okretaja, od toga je jedan činio potpuni pokret naprijed-natrag. Za Sonicare-Elite sa standardnom veličinom glave rabljeno je 12 000 okretaja, za Sonicare-Elite s "mini" glavom 18 000 okretaja te za Oral B - 12 500.

U postupku četkanja koristili smo se standardnom zubnom pastom pripremljenom od 247 grama glicerina, 247 grama deionizirne vode i 6,25 grama standardne komponente zubne paste-"zgušnjivača" (Merck, Darmstadt, Njemačka). Ta je mješavina poznata pod nazivom "Tragant" i može se čuvati nekoliko dana. Pasta s abrazivom pripremala se prije svakog mjerenja miješanjem 11,2 grama glicerina, 11,2 grama deionizirane vode, 44,2 grama otopine Tragant i 33,4 grama kalcijeva hidrogenfosfata. Nakon toga su se pastom ispunile komorice s dentinskim uzorkom, tako da su uzorci bili potpuno prekriveni. Sedimentacija je bila izbjegnuta, jer se držač uzorka u komorici pomicao ispod glave četkice omogućujući tijekom svakog okretaja stalno miješanje paste.

Analiza površine uzoraka

Analiza površine dentinskih uzoraka obavljena je uz pomoć 3D laserske triangulacije. Količina potrošenog dentina bila je izmjerena 3D laserskim skenerom (Scan-3D, Willytec, Munich, Njemačka). Skener ima vertikalnu rezoluciju manju od 10 μm, a lateralna rezolucija bila je namještena na veličinu 25 x 25 μm^2. Uzorci su snimljeni prije testa trošenja i nakon njega.

Površina uzorka bila je prije skeniranja prekrivena posebnim sprejem (Met-L-Chek Developer D-70, Helling GmbH, Spökerdamm 2, 25436 Heidgraben, Njemačka). Njegov točan sastav nije poznat, no prema tvrdnji proizvodjača sadržava otopljene tvari koje se brzo kristaliziraju kada su aplicirane na čistu površinu. Tako nastali kristali podjednake su veličine (manji od 10 μm) i nastaju samo u jednom soju. Kako bi se smanjio broj artefakta, stavljalo se vrlo malo spreja, tek toliko da potpuno pokrije ravnu ispoliranu površinu uzorka. Zbog toga neki od 3D podataka sadržavaju crne točkice, no one ne

A constant amplitude of 43 mm was determined based on the largest brush head, so that for the sinus curve this would ensure the same exposure conditions of the dentin to all brushes. The exposure time of the dentin samples to the brush head bristles was based on the brush head size, with shorter heads resulting in less exposure. To mimic clinically relevant brushing conditions the devices were subjected to three different strokes (1 stroke = one complete forward and backward motion). 12000 strokes were used for the Sonicare Elite with a standard size head, while 18000 strokes were used for the Sonicare Elite with the mini size head 18000. 125000 strokes were used for the control group with the Oral-B manual toothbrush.

The brushing was done with a standardized toothpaste slurry. The slurry was prepared from 247 g Glycerine, 247 g deionized water and 6.25 g Tragant (Merck, Darmstadt, Germany) (suspension thickener; a standard component of toothpaste). This mixture is called Tragant solution and can be easily stored for several days. The slurry containing the abrasive was freshly prepared before each test by mixing: 11.2 g Glycerine, 11.2 deionized water, 44.2 g Tragant solution, and 33.4 g Calciumhydrogenphosphate. The slurry was filled into the test chamber and the samples were totally covered with the slurry. Sedimentation was avoided because the specimen holder was moved below the toothbrush head in the slurry bath. This motion mixed the slurry continuously with every stroke.

Surface analysis

Surface analysis was done through 3D laser triangulation. The wear loss was measured with a 3D Laser Scanner (Scan-3D, Willytec, Munich, Germany). The scanner has a vertical resolution of less than 10 μm. The lateral resolution is set to 25 x 25 μm^2. The samples were digitized before and after the wear test. The specimen surface was digitized after polishing and the 3D data set was superimposed to a 3D-image acquired after testing.

The original surface of the specimen was covered with a special spray (Met-L-Chek Developer D-70, Helling GmbH, Spökerdamm 2, 25436 Heidgraben, Germany). The detailed information about the spray could not be obtained because the manufacturer does not disclose this information. We were told that the spray contains a dissolved material which rapidly crystallizes when applied to a clean surface. The manufacturer claims that the crystals are uniform in size, less than 10 μm and crystallize in one layer only. In order to ensure little artifacts due to the spray, very

utječu na rezultat, jer su automatski isključene iz evaluacije podataka.

Površina uzoraka bila je očišćena u ultrazvučnoj kupelji neposredno prije aplikacije spreja te skeniranja uzoraka i nakon toga. Dva seta 3D podataka superponiraju se prema područjima gdje uzorak nije oštećen četkanjem i na temelju toga dobiva se diferencijacijska snimka za statističku obradu podataka. Za vizualizaciju 3D podataka rabljen je postupak difuzne iluminacije kod kojega je izvor svjetla padao na površinu uzorka. S površine uzorka svjetlost se reflektira, a njezina količina predstavlja funkciju površinske inklinacije. Prosječan gubitak visine uporabljen je za usporedbu različitih ispitivanih skupina.

Za statističku analizu rezultata koristili smo se jednosmjernom analizom varijance (oneway ANOVA), te Tukeyjevim post-hoc testom.

Rezultati

U Tablici 1. zajednički je prikaz rezultata trošenja dentina za sve ispitivane skupine. Električna četikca za zube Sonicare-Elite sa standardnom veličinom glave i 90 grama vertikalnog opterećenja imala je najnižu vrijednost trošenja dentina. Nije ustanovljena statistički znatna razlika izmedju četkica Sonicare-Elite sa standardnom veličinom glave i 90 grama vertikalnog opterećenja, Sonicare-Elite sa standardnom veličinom glave i 150 grama vertikalnog opeterećenja te Sonicare-Elite s mini glavom i 90 grama opterećenja. Dvije ispitivane skupine - Sonicare-Elite s "mini" glavom i 150 grama vertikalnog opterećenja te manualna četkica za zube Oral-B pokazale su statistički veliku razliku (veće trošenje dentina) u odnosu prema već spomenutim eksperimentalnim skupinama. Nije utvrđena statistički znatna razlika izmedju dviju spomenutih ispitivanih skupina.

little spray is applied, just enough to cover the flat surfaces. This is the reason for the dark spots that can be seen in steep areas on the 3D data. However, this does not affect the result because they are excluded automatically from the evaluation.

The surface of the samples were cleaned in an ultrasound bath before coating with the spray immediately before the test and also after the test. The two 3D data sets are superimposed based on regions which were not worn by the toothbrush. Then a difference image was calculated and statistically analyzed. To visualize the 3D data, a diffuse illumination approach was used. It is assumed that a light source is illuminating the surface with an amount of light intensity, and that the surface reflects the light. The amount of reflected light is a function of the surface inclination. The mean height loss was used to compare the different test groups.

Statistical differences were calculated with a one-factorial analysis of variance (Oneway ANOVA). The Tukey-test was used as the post-hoc test.

Results

Table 1 summarizes the results of the experiment. Sonicare Elite power toothbrush with a standard head size at 90 g vertical load had the lowest dentine wear. No difference could be determined between: the Sonicare Elite with standard size brush head at 90 g vertical load, the Sonicare Elite standard brush head size at 150 g load, and the Sonicare Elite with mini head at 90 g load. The two groups: Sonicare Elite mini size brush head at 150 g vertical load and the manual Oral-B tooth brush were significantly different (higher wear) then the aforementioned group. No difference could be determined within the second subset.

Tablica 1. Prosječno trošenje dentina [µm] nakon završenog testiranja
Table 1 Mean dentine wear [µm] after testing

Skupina • Group	Prosječno trošenje dentina [µm] • Mean dentine wear [µm]	SD [µm]
Philips Sonicare-Elite standardna glava, 90g • Philips Sonicare Elite normal 90g	47.7	38.72
Philips Sonicare-Elite standardna glava, 150g • Philips Sonicare Elite normal 150g	58.82	49.05
Philips Sonicare-Elite mini glava, 90g • Philips Sonicare Elite small 90g	63.43	44.08
Philips Sonicare-Elite mini glava, 150g • Philips Sonicare Elite small 150g	97.71	72.04
Oral B-P35 kontrolna skupina, 150g • Oral B P35 (Control) 150g	107.26	50.44

Rasprava

Nakon što su se počele proizvoditi električne četkice odmah su se pojavile mnogobrojne laboratorijske i kliničke studije u kojima se uspoređivala njihova sigurnost i učinkovitost u odnosu prema klasičnim manualnim četkicama za zube. Općenito je uvriježeno mišljenje da su električne četkice sigurne kao i manualne (14). No, u nekim kliničkim studijama rezultati se razlikuju. Mišljenja o manualnoj i električnoj četkici te usporedbe nisu dali jasne rezultate. Neke prijašnje studije nisu dokazale prednosti električnih u odnosu prema manualnim četkicama, a u nekima se ističu prednost i veća učinkovitost u uklanjanju plaka te poboljšanje zdravlja gingive ako se primjenjuju električne četkice (15). Te proturječnosti u istraživanjima mogu se objasniti različitim pokusima i eksperimentalnim uvjetima (drugačijim brojem i oblikom uzoraka, načinom pripreme uzoraka, brojem okretaja četkice, vremenom četkanja, oblikom i vrstama glava četkice, primijenjenom silom, itd) pa je zato teško uspoređivati rezultate jedne studije s rezultatima druge (14,15).

Abraziju zbog četkanja uvjetuje niz čimbenika, kao što su čestoća četkanja, sile primijenjene tijekom četkanja, karakteristike glave četkice te vrsta i sastav paste (16). Eksperimenti in situ pokazuju zbog četkanja veću podložnost dentina demineralizaciji i abraziji u odnosu prema caklini (17-20). Sorensen i Nguyen (21) zaključili su da se manualna i električna četkica razlikuju u načinu prijenosa (raspodjele) paste koja na taj način rezultira različitom abrazijom tvrdoga zubnog tkiva. Istaknuli su i znatno veće trošenje dentina kod uporabe manualne četkice u usporedbi s električnom. Suprotno tome, Efraimsen i njegovi kolege (22) u svojem istraživanju nisu pronašli veću razliku u trošenju dentina izmedju uporabe manualne i električne četkice.

Ta studija težište stavlja na različito opterećenje dentinskog uzorka u primjeni električne četkice s različitim veličinama glave, u usporedbi s manualnom. Manualna četkica Oral-B P35 najviše troši dentin (107 μm), a najmanje Sonicare-Elite, električne četkice sa standardnom veličinom glave za oba primijenjena vertikalna opterećenja - od 90 i 150 grama. Zanimljivo je da standardna veličina glave kod 150 grama vertikalnog opterećenja uzrokuje manje trošenje dentina (58.82 μm), nego ista četkica s "mini" glavom i 90 grama vertikalnog opterćenja (63.43 μm). U slučaju "mini" glave sile su fokusirane na manju površinu, pa uporaba četkice s takvom glavom zahtijeva manje sile, odnosno pritiska tijekom četkanja. Iz Tablice 1. može

Discussion

The introduction of the powered toothbrush has lead to a large number of studies comparing the safety and efficacy of powered toothbrushes to manual toothbrushes. There is a general agreement that powered toothbrushes are as safe as manual toothbrushes (14). However, clinical studies designed to compare the efficacy of electric toothbrushing with that of manual toothbrushing have led to conflicting results. Opinions and comparisons between manual and power brushing have not led to unequivocal results. In the past, several studies have failed to show any benefit of an electric toothbrush over the use of a conventional manual toothbrush, whilst others have clearly demonstrated the electric toothbrush to be superior in terms of both plaque removal and improvement in gingival health (15). This conflict in study outcome can largely be explained by variations in study design. Most found no difference, but none found hand brushing to be superior to power brushing. A number of factors have a significant effect on results which vary between studies and are a probable reason for the variation in findings reported in the literature. Therefore, it is very difficult to compare the results of many studies, because they all use different brushing parameters. Differences can be seen in: sample preparing procedures, number of strokes, brushing time and forces, bristle shapes, composition of dentifrice, and experimental conditions (14,15).

The toothbrushing abrasion is influenced by brushing variables such as: frequency of toothbrushing, applied brushing forces, bristles characteristics, filament stiffness and end-rounding, composition of dentifrice (16). In situ studies found an increased susceptibility to demineralization and toothbrushing abrasion for dentine as compared to enamel (17,18). Currently, it is suggested that toothbrushing with manual and power toothbrushes produces limited dentine wear in lifetime of use (19,20). Sorensen and Nguyen (21) concluded that manual and powered toothbrushes differ in the transportation of dentrifice which leads to different abrasion of hard tooth tissue. They found significantly higher dentine loss produced by manual toothbrushes compared to powered toothbrushes. In the contrary, Efraimsen et al. (22) did not find any significant difference between powered and manual toothbrushing.

This study is focused on the different load applied to dentin substrate by powered toothbrushes with different brush head size compared to manual toothbrushes. Oral-B P 35, a manual toothbrush,

se vidjeti da nema statistički znatne razlike izmedju četkice Sonicare-Elite s "mini" glavom i 150 grama vertikalnim opterećenjem, u usporedbi s manualnom četkicom Oral-B.

U ovom ispitivanju rabila se standardna pasta. Vertikalno opterećenje od 150 grama i "mini" glava četkice s nekom drugom vrstom paste s više abrazivnih čestica, vjerojatno bi više trošilo dentin. U kliničkim uvjetima pokreti četkanja, vrijeme četkanja te četkanje nakon kiselih jela i pića, dodatni su čimbenici koji imaju velik učinak na trošenje dentina.

Manly i Foster (23) u svoju su studiju o trošenju dentina uključili i poziciju, odnosno položaj zuba. To je važan parametar u kliničkim uvjetima, ali nažalost malo je istraživanja u kojima se ispitivalo trošenje dentina s obzirom na položaj zuba u čeljusti. Spomenuti autori zaključili su da je trošenje ravnomjerno raspoređeno uz cerviks zuba. Različito primijenjeno opterećenje na zub u različitom položaju u zubnom luku, u slučaju električnih četkica za zube s povratnim sustavom nakon prekoračenja kritične sile, vjerojatno neće imati znatan utjecaj na ukupan gubitak dentina (16). No, to će tek biti predmet istraživanja.

McConnell i Conroy (12) ispitivali su manualne četkice kod 167 i 250 grama opterećenja te pronašli gubitak dentina od 57 do 118 mg. Noordmans i suradnici (24) u svojoj su studiji zaključili da se trošenje dentina kreće od 4 do 35 μm na tjedan uz 100 okretaja kod četkanja sa zubnom pastom. O gubitku dentina od 0,02 do 0,06 μm govori se, pak, u studijima Zimmera i njegovih kolega. (3). Van der Weijden i suradnici (25) zaključili su da se kod uporabe električnih četkica primjenjuju manje sile tijekom četkanja nego kod manualnih. U novijim studijama također se ističe da se kod električnih četkica primijenjene sile kreću uglavnom od 80 do 190 grama, a kod manualnih 250 grama (16).

No, očito je da pacijent mora dobiti odgovarajuće informacije o četkanju i načinu primjene novih električnih četkica za zube, kako bi se osigurala njihova pravilna uporaba te postigao maksimalni učinak oralnog zdravlja s manje karijesa, zadržavanja plaka, dentinske preosjetljivosti i cervikalnih lezija.

causes the highest dentin loss (107 μm), while the lowest loss was recorded with the Sonicare Elite power toothbrush with a standard head size for both 90 g and 150 g vertical loads. It is interesting that standard head size head at 150 g vertical load causes less dentin loss (58.82 μm) than a mini head size with 90 g applied vertical load (63.43 μm). In the case of the mini head size, the forces are focused on lower surfaces, and therefore the use of the mini head size requires less force to be applied. From Table 1 it is also seen that there is no significant difference between the Sonicare Elite with mini bristle head size at 150 g vertical load, and the Oral-B manual toothbrush.

In this study standard slurry was used. Load at 150 g, and mini bristle size with some other dentrifice with more abrasive characteristics will probably lead to even higher dentine loss. Furthermore, in clinical conditions: brushing motions, brushing time and brushing after exposure of acidic food and drinks will also be of great influence to dentine loss.

In their dentine wear study, Manly and Foster (23) also investigated the position of the tooth. Tooth position is a very important parameter in clinical situations, but unfortunately there are very little or no recent findings on how tooth position influences the amount of dentine loss. They found that wear is uniformly distributed around the cervix of the tooth. The different loads applied on different teeth at different positions in the dental arch, will probably not influence significantly the final dentine loss values when considering powered toothbrushes with feedback systems after critical forces have been applied (16). The aforementioned will be the subject of further studies.

In their study, McConnell and Conroy tested (12) manual brushes with 167 and 250 g loads and found dentine loss from 57 to 118 mg. Noordmans et al. (24) found in their in situ study wear rates of dentine between 4 and 35 μm weekly with 100 strokes of brushing with toothpaste. Despite these findings, wear loss of 0.06 and 0.02 μm was established in a study conducted by Zimmer et al. (3). Van der Weijden et al. (25) have found that less brushing force is used with electric than with manual toothbrushes. The forces for powered toothbrushes are usually in the 80-190 g range, and in the 250 g range for manual toothbrushes (16).

However, it is evident that subjects should receive specific toothbrushing and operative instructions with new powered tooth brush devices. This

Zaključak

Rezultati ovog ispitivanja pokazali su da manualna četkica više troši dentin u odnosu prema električnima. U skupini električnih četkica najveće trošenje dentina zabilježeno je kod uporabe četkice s "mini" glavom, bez obzira na veličinu vertikalnog opterećenja.

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is to ensure correct use which will result in better oral health with: less plaque retention, caries, dentine hypersensitivity and cervical lesions.

Conclusion

This study confirmed that manual toothbrushes cause more dentine wear than powered toothbrushes. Also, a greater load and smaller brush head size of powered toothbrushes leads to higher dentine substrate loss and greater wear regardless of the load applied.

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Abstract

Purpose: The aim of this study was to evaluate the dentine wear after brushing with powered toothbrushes with different brush head size and different load applied in comparison with manual toothbrush. **Material and Methods:** Powered toothbrush Sonicare Elite with mini and standard size brush heads at 90g and 150g vertical load, and the manual toothbrush Oral-B-P35 with a vertical load of 150g, were used as a control group. Toothbrushing machine with different number of strokes was used for dentine abrasion assessment. For Sonicare-Elite with standard size head 12000 strokes was used, for Sonicare Elite with mini head 18000 and for manual toothbrush 12500 strokes. 3D-Laser scan was used for evaluation of dentine wear. The highest dentine wear was recorded using manual toothbrush (107.26μm), while the lowest using Sonicare-Elite with standard size head at 90g vertical load (47.7μm). **Results:** No statistical significance was found between powered toothbrushes with: mini head (90g load), standard head (90 and 150g load) and between mini head of powered toothbrushes at 150g vertical load and manual toothbrush. **Conclusion:** Powered toothbrushes with different brush head size and different load applied caused different tooth wear: the smaller the brush head and the higher the load is, the higher the dentine wear is.

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