Comparison of Fluoride Ion Release from Fluoride Gel in Various Solvents

Usporedba otpuštanja iona fluora iz fluoridnih gelova u različitim otapalima

Introduction

High concentration fluoride gels are used for caries prevention and therapy (1). A variety of fluoride compounds (e.g. sodium fluoride, amine fluoride, stannous fluoride, silane fluoride) are used as topical prophylaxis agents, however, all of them must meet one basic requirement – fluoride ion liberation. It is considered important for fluoride ion concentration to be even slightly increased in the proximity of the tooth surface for the remineralization to be effective (2, 3, 4).

Sodium fluoride, an inorganic and very soluble salt, readily releases F⁻ ions and its effectiveness has been proven many times. Amine fluorides, on the other hand, contain covalently bonded fluorine. Amphipathic character advantages them to stay in contact with the tooth surface during longer periods. The available data of research are unclear in regard to superiority of one of them in remineralization, but both compounds are proven effective in caries prevention (5). Since fluoride ions are very reactive, they become ineffective easily. Eggert and Neubert investigated the liberation of fluoride ions from toothpastes and concluded that fluoride ion release is modified depending on auxiliaries present in the product (6).
Topical fluorides are of great importance for cancer patients treated with radiation therapy in the region of head and neck. Irradiated salivary glands deteriorate in function leading to dry mouth, changes in oral environment and radiation caries. A failure in excellent oral hygiene maintenance and topical fluoridation regime leads to rampant caries development (7, 8, 9). Caries can be successfully prevented if high concentration fluoride gels are used in custom trays. Fluoridation protocols are proposed for facilitating the use. Zandim et al. recommended the use of a 0.025% NaF mouth rinse together with artificial saliva for radiation-induced hyposalivation patients, and Abdalla et al. recommended a mouth rinse containing 0.05% NaF and 0.12% chlorhexidine-gluconate twice-a-day (10, 11). The latter combination of fluorides and antimicrobial agent might be more effective due to their effect both on the demineralization-remineralization process and oral microbes as found by Abdalla et al. (11).

The aim of this study was to determine the concentration of free fluoride ions, using solutions which may be used for xenostomia therapy that served us as solvents – in order that fluoride ion interactions can be assessed as a first step for further investigation of alternative topical fluoridation protocols.

The null hypothesis was that there is no difference in F– ions release from various fluoride gels in different solvents, therefore, there is no deviation from the label amount of F– concentration.

Material and methods

Study samples selection

Two fluoride gels containing different active ingredients were used in this study. The information about the products is presented in Table 1.

Five different solvents were used: distilled water (Iskra d.d., Sv. Ivan Zelina, Croatia), redistilled water (the institution), tap water (the institution), 0.9% sodium chloride solution – saline (Natrii chloridi influndibile Pliva, Pliva Hrvatska d.o.o., Zagreb, Croatia) and artificial saliva Axerosta (Mages Plant Sp. z o.o., Warsaw, Poland).

The samples were measured with the analytical balance ABS 80-4N (Kern & Sohn GmbH, Balingen, Germany) and the automatic pipette Eppendorf Research® (Eppendorf, Hamburg, Germany) in polystyrene vials (Ratiolab, Germany).

The measuring electrode used was the fluoride-selective electrode type 96 – 09 (Thermo Scientific, Waltham, Massachusetts, USA) with the microprocessor analyzer ORION EA 940® (Orion Research Inc., USA). Samples were stirred at 500 rpm on the magnetic stir plate (IKA-Werke GmbH & Co. KG, Staufen, Germany) during the entire measuring process.

Fluoride concentration measurements

The international standard ISO 19448 was used as a reference for the methodology (12).

Fluoride gels and solvents are left at the room temperature. To achieve the product homogeneity, a bottle of sodium fluoride gels and solvents in different solvents, therefore, there is no deviation from the label amount of F– concentration.

Topical fluorid vrlo su važni za pacijente s malignom bolešću ako su liječeni zračenjem u području glave i vrata. Naime, ozračene žlijezde slinovnice gube svoju funkciju, što rezultira suhoćom usta, promjenama u oralnom okolisu i radijacijskim karijesom. Nesuđep u izvršnom održavanju oralne higijene i topikalnom režimu fluoridacije potiče pojava opsežnih karijesnih lezija (7, 8, 9). To posljednje može se uspješno spriječiti ako se u individualnim udlagama primjenjuju fluoridni gelovi s visokim koncentracijama fluorida.

Predloženi su jednostavniji protokoli za topikalnu fluoridaciju. Zandim i suradnici preporučili su korištenje 0,025-postotne NaF otopine za ispiranje usta zajedno s umjetnom slinom za bolesnike s hiposalivacijom induciranim zračenjem, a Abdalla i suradnici savjetovali su ispiranje usta otopinom koja sadržava 0,05% natrijeva fluorida i 0,12% chlorhoksidin-glukonata dva puta na dan (10, 11). Kombinacija fluorida i antimikrobnog sredstva može biti učinkovitija zbog utjecaja i na demineralizacijsko-remineralizacijski proces i oralne mikrobe, kako su opisali Abdalla i suradnici (11).

Cilj ovog istraživanja bio je odrediti koncentraciju slobodnih fluoridnih iona u otopinama koje bi se mogle upotrijebiti u terapiji kserostomije, a koja su nam poslužila kao otapača kako bi se dobio uvid u ionske interakcije fluorida, što je prvi korak u daljnjem istraživanju alternativnih protokola topikalne fluoridacije.

Nušta hipoteza glasila je da nema razlike u otpuštanju F– iona iz različitih fluoridnih gelova u različitim otapalima te da zato nema odstupanja od deklarirane koncentracije F– iona.

Materijali i metode

Odarib uzoraka

U ovom istraživanju korištena su dva fluoridna gela koja sadržavaju različite aktivne sastojke. Informacije o proizvodima nalaze se u tablici 1.

Korišteno je pet različitih otapala: destilirana voda (Iskra d.d., Sv. Ivan Zelina, Hrvatska), redestilirana voda (the institution), 0,9-postotna otopina natrija (Natrii chloridi influndibile Pliva, Pliva Hrvatska d.o.o., Zagreb, Hrvatska) i artifical saliva Axerosta (Mages Plant Sp. z o.o., Warszaw, Polska).

Uzorci su izmjereni analitičkom vagom ABS 80-4N (Kern & Sohn GmbH, Balingen, Germany) i automatnom pipetom Eppendorf Research® (Eppendorf, Hamburg, Niemacka) u polystirenima čašicama (Ratiolab, Niemacka).

Korištena mjerna elektroda bila je fluorno-selektivna elektroda tipa 96 – 09 (Thermo Scientific, Waltham, Massachusetts, USA) s analizatorom ORION EA 940® (Orion Research Inc., USA). Tijekom cijelog mjernog procesa uzroci su miješani u sredini – saline (institucija), voda iz slavine (izdeljnik), 0,9-postotna otopina natrijeva klorida – fiziološka otopina (Natrii chloridi influndibile Pliva, Pliva Hrvatska d.o.o., Zagreb, Hrvatska) i umjetna slina Axerosta (Mages Plant Sp. z o.o., Warszaw, Polska).

Mjerenje koncentracije fluorida

Međunarodna norma ISO 19448 korištena je kao referencija za metodologiju mjerenja (12).

Fluoridni gelovi i otapači ostavljeni su na sobnoj temperaturi. Prije njihova otvaranja, kako bi se osigurala homoge-
fluoride only was shaken and the gel tube containing amine fluoride and sodium fluoride was kneaded prior to opening. Subsequently, 1 cm of each product was dispensed and discarded. The samples were obtained from the remaining product.

Five samples were prepared from each fluoride gel to be dissolved in five different solvents. A polystyrene vial was placed on a balance and the balance was tarred. 0.055 g of the gel product was then added to the vial. Distilled water, re-distilled water, tap water and saline solution were added to each particular vial with automatic pipette in volume of 5.5 ml. The artificial saliva product was difficult to pipette due to its viscosity. Therefore, the vial containing fluoride gel sample was placed on the balance and the artificial saliva product was added to the vial to the total mass of 5,555 g.

The direct analysis technique was used to determine the amount of fluoride ion concentration.

Prior to the analysis of the solutions, the accuracy of the measuring instrument was checked as well as the electrode inclination according to the manufacturer’s instructions. After that, the measuring instrument was calibrated at room temperature over the range of 19 ppm F− to 190 ppm F−.

Each vial containing the sample was placed on the magnetic stir plate and the magnetic stir bar was added, then the fluoride-selective electrode was immersed in the solution. For each sample 10 measurements were performed and expressed in mgF/l (ppm F−). Prior to measuring F− ion concentrations in pure solvents, the measuring instrument was once more calibrated at room temperature over the range of 0.19 ppm F− to 1.9 ppm F−. The direct analysis technique was used as has already been described in the previous paragraph.

Statistical analysis

Since 0.055 g of fluoride gel was dissolved in 5,5 ml of solvent, the dilution factor was 100. Therefore, all the measured values were multiplied by 100 prior to the statistical analysis.

Descriptive statistics were used and a paired two-sample for means t-test was used to determine if there were significant differences between the measured fluoride concentration and the concentration value listed on the label. The ANOVA was used to determine if there were significant differences between the liberation of fluoride ions from each gel in each particular solvent.

Furthermore, the ANOVA was used to determine if there were significant differences between the liberation of fluoride only, bočica NaF gela je promučkana, a tuba gela s NaF-om i aminofluoridima je grijana. Zatim se iz svakog pakiranja istisnuo i odbacio 1 cm gela, a uzorci za mjerenje pripravljeni su od ostatka sadržaja u tubi.

Pripremljeno je pet uzoraka od svakoga gela kako bi se otopili u pet različitih otapala. Polistirenova čašica stavljen je na vagon i vaga je tarirana. U čašici je zatim dodano 0,055 g gela. Zatim su u svaku polistirenovu čašicu dodane destilirana voda, redestilirana voda, voda iz slavine i fiziološka otopina omotaćima pipetom u volumenu od 5,5 ml. Zbog velike viskoznosti preparata umjetne sline, pipetiranje je bilo otežano.

Zato je čašica s uzorkom fluoridnog gela postavljena na analitičku vagu i u nju je pipetom dodan preparat umjetne sline do ukupne mase uzorka od 5,555 g.

Izravna metoda mjerenja korištena je za određivanje količine koncentracije fluorida iona.

Pripje se uzorak provjerio je ispravnost i nagib elektrode prema uputama proizvođača, a zatim je uredjak kalibriran pri sobnoj temperaturi za mjerenje koncentracija u rasponu od 19 ppm F− do 190 ppm F−.

Svaka čašica s uzorkom postavljena je na magnetsku mijesalicu i dodan je štapić za miješanje, a zatim je fluor-selektivna elektroda uronjena u otopinu. Za svaki uzorak učinjeno je deset očitanja koncentracije i vrijednosti koncentracije izražene su u mgF/l (ppm F−).

Pripje se koncentracije F− iona u čistim otapala, fluor-selektivna elektroda ponovno je kalibrirana za mjerenje koncentracija u rasponu od 0,19 ppm F− do 1,9 ppm F−.

Primijenjena je tehnika izravne analize, kao što je već opisano.

Statistička analiza

Budući da je 0,055 g fluoridnog gela otopljeno u 5,5 ml otapala, analizirani uzorci fluoridnih gelova bili su razrijedjeni 100 puta. Zato su prije analize i obrade podataka sve očitane vrijednosti pomnožene s korekcijskim faktorom 100.

Podatci su obrađeni metodama deskriptivne statistike, a za utvrđivanje postoji li značajna razlika između deklarirane i izmjerene koncentracije fluorida korišten je t-test za zavisne uzorke. Za utvrđivanje razlika u optuštanju F− iona iz pojedinog gela u svakom otapalu korištena je ANOVA.

Statistički test postoji li razlika u optuštanju F− iona između NaF gela i gela koji sadržava NaF i aminofluorid u istim otapala, korišten je također ANOVA test.

| Table 1 | Fluoride gels | Tablica 1. | Fluoridni gelovi |
|--------|---------------|------------|-----------------|
| **Fluoride gel • Naziv gela** | **Product/supplier • Proizvod/proizvođač** | **Fluoride compound and its amount in 10 g of a gel • Fluoridni spoj i njegova količina u 10 g gela** | **Label amount of fluoride concentration • Deklarirana koncentracija fluora** |
| Sodium fluoride only • Gel s natrijevim fluoridom | Miradent Mirafluor - gel (Hager & Werken GmbH & Co. KG, Duisburg, Germany • Njemačka) LOT 208702 | NaF 0.272 g | 12300 ppm F− |
| Amine fluoride and sodium fluoride • Gel s aminofluoridima i natrijevim fluoridom | Elmex Gel (CP GABA GmbH, Hamburg, Germany • Njemačka) PZN 01427249 | dextaflur 0.0287 g | olafur 0.3032 g | NaF 0.2210 g | 12500 ppm F− |
de ions from sodium fluoride only gel and the gel containing amine fluoride and sodium fluoride in the same solvents.

The Post hoc Tukey's test was used for multiple comparisons between each of the solutions.

The significance level for all tests was \( \alpha = 5\% \).

**Results**

F- ion concentrations measured in pure solvents are presented in Table 2.

Mean measured concentrations of fluoride ions in solutions of gel are presented in Tables 3 and 4.

A statistically significant difference between the measured fluoride concentration and the concentration value listed on the label was determined both for sodium fluoride only gel and gel containing amine fluoride and sodium fluoride by the use of a paired two-sample for means t-test.

Furthermore, the results suggested that there were some differences in the liberation of fluoride ions in different solvents. The Post hoc Tukey's test was then used to determine individual differences in the liberation of fluoride ions from each gel in each particular solvent. There was a significant difference in fluoride ion release in every sodium fluoride only gel solution. However, there was not a significant difference between distilled and redistilled water solutions. Fluoride ion release in solvents 2 and 4, 2/5 no significant difference between solvents 2 and 5, 3/4 significant difference between solvents 3 and 4, 3/5 significant difference between solvents 3 and 5.

A statistically significant difference between the measured fluoride concentration and the concentration value listed on the label was determined both for sodium fluoride only gel and gel containing amine fluoride and sodium fluoride by the use of a paired two-sample for means t-test. Furthermore, the results suggested that there were some differences in the liberation of fluoride ions in different solvents. The Post hoc Tukey's test was then used to determine individual differences in the liberation of fluoride ions from each gel in each particular solvent. There was a significant difference in fluoride ion release in every sodium fluoride only gel solution. However, there was not a significant difference between distilled and redistilled water solutions. Fluoride ion release in solvents 2 and 4, 2/5 no significant difference between solvents 2 and 5, 3/4 significant difference between solvents 3 and 4, 3/5 significant difference between solvents 3 and 5. Post hoc Tukey's test was used for multiple comparisons between each of the solutions. The significance level for all tests was \( \alpha = 5\% \).

**Table 2** F ion concentration in pure solvents

**Table 3** F ion concentration in sodium fluoride only solutions

**Post hoc Tukey's test** was then used to determine individual differences in the liberation of fluoride ions from each gel in each particular solvent. There was a significant difference in fluoride ion release in every sodium fluoride only gel solution. However, there was not a significant difference between distilled and redistilled water solutions. Fluoride ion release in solvents 2 and 4, 2/5 no significant difference between solvents 2 and 5, 3/4 significant difference between solvents 3 and 4, 3/5 significant difference between solvents 3 and 5.
ride ion release was significantly different in every solution of gel containing amine fluoride and sodium fluoride except between distilled and redistilled water solutions and between redistilled water and artificial saliva solutions.

The ANOVA showed statistically significant differences between the liberation of fluoride ions from sodium fluoride only gel and gel containing amine fluoride and sodium fluoride in the same solvents. The Post hoc Tukey's test revealed that significant differences exist between all the solvents except for distilled water.

Discussion

In clinical situations it is necessary to recommend reliable therapies with predictable and consistent outcomes. Therefore, it is important to have insight into possible chemical interactions which may influence the effectiveness of topical fluorides (13).

Cate et al. proved that the remineralization of advanced enamel lesions benefits from more concentrated fluoride treatment (14). Therefore, the first step was to determine whether the label amount of fluoride ions corresponded with the readily available F− ions in fluoride gels. Depending on which fluoride compound is added to a dentifrice and which fluoride fraction is measured, various analytical methods can be used (15). The results suggest that there is a difference between the measured fluoride concentration and the concentration value listed on the label both for sodium fluoride only and the gel containing amine fluoride and sodium fluoride. However, in this study, it has been determined that concentrations of F− ions in redistilled water were higher than the label amount of fluoride ion concentration in both gels, sodium fluoride and amine fluoride gel, which indicates that all the fluoride compounds form both gels dissolved entirely. F− ion concentrations in pure solvent samples, in this study, were negligibly low.

ANOVA is the method typically used to determine whether a significant difference exists between the groups. If the ANOVA test yields a significant result (P < 0.05), further analysis is performed to determine which groups differ significantly from each other. Post hoc tests are often used to make these comparisons. Tukey's test is one of the most commonly used post hoc tests. It is a multiple comparison test that compares all possible pairs of groups to determine which groups differ significantly from each other.

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and could not increase F\(^-\) ion concentrations in fluoride gels solutions. Fluoride ion concentration measured in tap water corresponded to the previously published data (16).

The measured higher concentrations might be a repercussion of Total Ionic Strength Adjustment Buffer (TISAB) (which is prescribed by ISO 19448:2018 standard) not being added to the tested solutions. When fluoride-selective electrode is used, different buffers can be utilized. Those buffers modify the electrode sensitivity and measurement precision (17). The TISAB was not used in this study because only ion interactions in various solvents can be observed.

The results showed that there was a significant difference in the fluoride ion liberation from fluoride gels in various solvents.

Fluoride ion concentration in sodium fluoride only and tap water solution was significantly lower than concentration measured in solution of sodium fluoride in distilled and redistilled water. Tap water contains various ions dissolved which interact with F\(^-\) ions. Calcium ions bind F\(^-\) ions and tap water contains high amount of calcium ions (16). On the other hand, significantly higher fluoride ion concentration was measured in the solution of sodium fluoride only gel in saline than in other sodium fluoride only solutions. Martinez-Mier et al. investigated the methods for measurements of fluoride ions in table salt and possible interferences of the presence of NaCl and other ions in the salt with the measurement of fluoride ions by use of fluoride-selective electrode (18). In their study, their results obtained using F standards with NaCl added produced an overall 10% increase in fluoride ion values. Since saline solution contains sodium chloride, Cl\(^-\) ions could interact with Na\(^+\) ions from NaF and make more F\(^-\) ions free. Furthermore, F\(^-\) ion concentration measured in the solution of sodium fluoride only gel in artificial saliva was higher than those in all the other sodium fluoride only solution except for the one in saline. The artificial saliva product, according to the label, contains citrates and acetates. According to several studies, citrates and acetates are also responsible for the liberation of F\(^-\) ions in fluoride gels in various solvents. According to Table 4 and Table 1, the measured concentration of F\(^-\) ions in tap water solution of gel containing amine fluoride and sodium fluoride corresponds to the amount of amine fluoride in the gel product. As described in the previous paragraph, different ions (primarily Ca\(^{2+}\) ions) present in tap water interacted with NaF, which resulted in lower concentration being measured.

Izmjene veće koncentracije mogu biti posljedica nekorištenja puferskog sustava Total Ionic Strength Adjustment Buffer (TISAB) (propisan je normom ISO 19448:2018) u ispitivanim otopinama. Kada se upotrebljava fluorid-selektivna elektroda, mogu pojaviti različiti puferi. Puferi mijenjaju osjetljivost elektrode i preciznost mjerenja (17). TISAB se nije koristio u ovom ispitivanju kako bi se procijenile isključivo interakcije iona u različitim otapalima.

Rezultati su pokazali da postoji značajna razlika u otpuštanju fluoridnih iona iz fluoridnih gelova u različitim otapalima.

Koncentracija fluoridnih iona u otopini gela koji sadržava samo natrijef fluorid i vode iz slavine bila je značajno niža od koncentracije izmjerene u otopini NaF gela u destiliranoj i redestiliranoj vodi. Voda iz slavine sadržava različite otoplejne ione koji ulaze u interakciju s F\(^-\) ionima. Kalcevi ioni vežu F\(^-\) ione, a voda iz slavine sadržava veliku količinu kalcevih iona (16). S druge strane, značajno veća koncentracija fluoridnih iona izmjerena je u otopini gela s natrijevim fluoridom u fiziološkoj otopini, negoli u drugim otopinama istoga gela. Martinez-Mier i suradnici istraživali su metode mjerenju fluorida u kuhinjskoj soli i moguće poteškoće pri mjerenju fluorid-selektivnom elektrodom zbog prisutnosti NaCl-a i drugih iona u kuhinjskoj soli (18). U njihovu istraživanju, korištenjem F standarda s dodanim NaCl-om, izmjerene su 10% veće vrijednosti fluoridnih iona. Budući da fiziološka otopina sadržava natrijev klorid, Cl\(^-\) ione ulaze u interakciju s Na\(^+\) i ionima iz NaF-a i oslobađaju više F\(^-\) iona. Nadalje, koncentracija F\(^-\) iiona izmjerena u otopini NaF gela u umjetnoj slini bila je veća od one u svim ostalim otopinama NaF gela, osim u fiziološkoj otopini. Preparat umjetne sline, prema deklaraciji, sadržava citrate i acetate. Prema podacima iz nekoliko istraživanja, citrate oslobađaju fluorid iz ionskih kompleksa (19). Acetati, koji su dio TISAB-a, također su odgovorni za oslobađanje F\(^-\) iona (20, 21). Unatoč tomu, u ovom se istraživanju ne može raspravljati o bioraspoloživosti natrijev fluorida u fiziološkoj otopini i otopini umjetne sline, ali može biti položite za daljnja istraživanja.

Gel u kojem su aminofluoridi i natrijev fluorid sadržava aminofluorida u većoj količini od NaF-a. Kovalentno vezani fluor u aminofluoridima ne disocira na isti način kao ionski fluor iz NaF-a. Kada se promatraju izolirano, razlike u otopinama gela koji sadržavaju i aminofluoride i natrijev fluorid postoje između svih otopina.

Koncentracije fluorida u otopini gela koji sadržavaju i aminofluoride i natrijev fluorid u vodi iz slavine znatno su niže od onih istoga gela u drugim otapalima. Prema tablici 4. i tablici 1. izmjerena koncentracija F\(^-\) iona u otopini gela koji sadržava i aminofluoride i natrijev fluorid u vodi iz slavine, odgovara količini aminofluorida u gelu. Kao što je opisano u gornjem odlomku, različiti ioni (ponajprije Ca\(^{2+}\) ioni) u vodi iz slavine u interakciji su s NaF-om, što je rezultiralo mjerenju niže koncentracije.

Kada se otopine gela koji sadržava aminofluoride i natrijev fluorid uspoređuju s otopinama NaF gela, potvrdila se stabilnost aminofluorida. Koncentracije F\(^-\) iona u otopinama gela s aminofluoridima i NaF-om u fiziološkoj otopini i umjetnoj slini razlikuju se, ali su mnogo bliže otopini toga.
When solutions of the gel containing amine fluoride and sodium fluoride are compared with sodium fluoride only solutions, the stability of amine fluorides is verified. F⁻ ion concentrations in saline and artificial saliva solutions of gel containing amine fluoride and sodium fluoride differ but are much closer to the redistilled water solution of that gel. Those concentrations are almost three times lower than F⁻ concentration in the solutions of sodium fluoride only in the same solvents due to lack of ion interactions between amine fluorides and other ions present in the solutions.

The limitations of this analysis relate to the sample and analysis methods. The analysis methods were based on a relatively new ISO 19448:2018 standard. ISO 19448:2018 standard was supposed to be a generic guideline, which does not make a distinction between fluoride compounds. The method should be acceptable for the analysis of fluoride in aqueous samples derived from all fluoridated dental products.

We made a modification to the ISO 19448:2018 standard and did not add TISAB to the solutions, which might have influenced the measurement, as mentioned earlier. In the absence of an additional, well-established, method of analysis being used on the same samples (i.e. liquid gas chromatography (22)) it is not possible to completely assess the validity of the ISO 19448:2018 standard.

The study used a small, non-systematic convenience sample of fluoride gels, using only one sample of each type. Without reliable and comprehensive guidelines on the composition of fluoride gels, it is not possible to extrapolate effectiveness of the gels based on the fluoride content. However, this study observed ionic interactions, which might affect the demineralization-remineralization process in vivo.

Conclusion

Sodium fluoride and amine fluorides differ in fluoride ion delivery mechanisms. Amine fluorides do not interact with other ions present in the solution, whereas F⁻ ion release from sodium fluoride alters when other ions are dissolved in the same solution. Furthermore, the greater amount of F⁻ ions is released from NaF in the solutions which contain chlorides, citrates and acetates. Given that, it should be noted that amine fluorides are more stable compounds as fluoride delivery system and may deliver F⁻ ions more efficiently for caries prevention in patients suffering from xerostomia after radiation therapy.

Conflict of interest

None declared

Acknowledgements

The authors thank Ankica Técic for her technical assistance.

This study was supported by the Croatian Ministry of Science and Education (grant for University institutional science funding).

The study was presented at 9th Croatian Congress of Pharmacology with International Participation, Zagreb, Croatia (28 September 2019)

gela u redestiliranoj vodi. Te su koncentracije gotovo tri puta niže od koncentracija F⁻ iona u otopinama NaF gela u istim otapalima zbog nedostatka interakcija iona između aminofluorida i drugih iona prisutnih u otopinama.

Ograničenja ovog istraživanja odnose se na uzorke i metode.

Metodologija se temeljila na razmjerno novom standardu ISO 19448:2018. Taj je standard trebao biti generička smjernica koja ne čini razliku između fluorida u spojevima. Metoda bi trebala biti prihvatljiva za analizu fluorida u vodenim otopinama svih fluoridiranih proizvoda za oralnu higijenu.

Modificirali smo standard ISO 19448:2018 i otopinama nismo dodali TISAB, što je moglo utjecati na mjerenje, kao što je već spomenuto.

U nedostatku dodatne validirane analitičke metode koja se koristi na istim uzorcima (npr., plinska kromatografija (22)) nije moguće u cijelosti procijeniti valjanost standarda ISO 19448:2018.

U studiji je upotrijebljen malen, nesistematičan i prikladan uzorak fluoridnih gelova, koristeći se samo jednim uzorkom svake vrste.

Bez pouzdanih i sveobuhvatnih podataka o sastavu fluoridnih gelova nije moguće ekstrapolirati njihovu učinkovitost na temelju sadržaja fluorida. No u ovom smo istraživanju promatrali ionske interakcije koje mogu utjecati na proces demineralizacije-remineralizacije in vivo.

Zaključak

Natrijev fluorid i aminofluoridi razlikuju se u mehanizmima dostave fluoridnih iona. Aminofluoridi ne ulaze u interakciju s drugim ionima u otopini, a oslobađanje F⁻ iona iz natrijeva fluorida mijenja se ako se drugi ioni nalaze u istoj otopini. Nadalje, veća količina F⁻ iona oslobađa se iz NaF-a u otopinama koje sadržavaju kloride, citrate i acetate. S obzirom na to treba napomenuti da su aminofluoridi stabilniji spojevi za dostavu fluorida i mogu učinkovitije isporučiti F⁻ ione za prevenciju karijesa pacijentima koji pate od kserostomije nakon terapije zračenjem.

Sukob interfer

Autori nisu bili u sukobu interfer.

Zahvale

Autori zahvaljuju Ankici Tečić na pomoći u laboratoriju.

Rad je financiralo Ministarstvo znanosti i obrazovanja (namjensko višegodišnje institucijalno financiranje znanstvene djelatnosti, potpore Sveučilišta u Zagrebu).

Rezultati ovog istraživanja predstavljeni su na 9. Hrvatskom kongresu farmakologije s međunarodnim sudjelovanjem (Zagreb, Hrvatska, 28. rujna 2019.).
Sažetak

Cilj: U istraživanju se željela odrediti koncentracija fluorida u različitim otapalima i usporediti je s deklariranim koncentracijama. Materiał i metode: Gel koji sadržava aminofluorid i natrijev fluorid uspoređen je s gelom samo s natrijevim fluoridom. Otapala korištena u ovom istraživanju bila su destilirana voda, destilirana voda, voda iz slavine, 0,9-postotna otolina natrijev klorid i umjetna slina. Količina fluoridnih iona (F⁻) određena je fluor-selektivnom elektrodom. Korišteni su ANOVA i post hoc Tukeyjev test. Razina značajnosti bila je α = 5 %. Rezultati: Razlike između otapanja F⁻ iona u različitim otapalima bile su statistički značajne (p < 0,05). Koncentracija F⁻ iona izmjerena u otopinama redistilirane vode obaju gelova bila je viša od deklariranih koncentracija. Zabilježena je značajna razlika u otapanju fluorida između otopina gela koje su sadržavale samo natrijev fluorid. Oslobađanje fluoridnih ionih bilo je značajno različito u otopinama kombiniranoga fluoridnog gela.

Zaključak: Aminofluoridi ne stupaju u interakciju s drugim ionima u otopini, a otapanje F⁻ iona iz natrijeva fluorida mijenja se kada su u istoj otopini i drugi ioni. Aminofluoridi učinkovitije dostavljaju F⁻ ione za prevenciju karijesa.

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