

Antonija Tadin^{1,2}, Sara Galic³, Lidia Gavić¹

Assessment of Color Change, Esthetic Perception, Treatment Satisfaction, and Side Effects Following the Use of Over-the-Counter Whitening Products

Procjena promjene boje, estetske percepcije, zadovoljstva tretmanom i nuspojava poslije korištenja komercijalnih proizvoda za izbjeljivanje

¹ Department of Restorative Dental Medicine and Endodontics, Study of Dental Medicine, University of Split School of Medicine, 21000 Split, Croatia

Katedra za restaurativnu dentalnu medicinu i endodonciju Medicinskog fakulteta Sveučilišta u Splitu, Hrvatska

² Department of Maxillofacial Surgery, Clinical Hospital Centre Split, 21000 Split, Croatia

Zavod za maksilofacijalnu kirurgiju Kliničkoga bolničkog centra Split, Hrvatska

³ Private dental office, 20350 Metkovic, Croatia

Privatna ordinacija, Metković, Hrvatska

Abstract

Objectives: The objective of this study was to investigate the efficacy of tooth whitening and the effects on satisfaction with whitening treatment and esthetic self-perception of over-the-counter tooth whitening products. **Materials and methods:** Fifty-six participants were randomly allocated to three groups based on the whitening product they used (toothpaste, pencil, or a combination of both). In this prospective study, alterations in tooth color were assessed using a spectrophotometer at three distinct time intervals (initial measurement, seven days, and 14 days after commencing the use of the whitening product). Simultaneously, the respondents were given the PIDAQ questionnaire to complete. Patient satisfaction with treatment characteristics (5-point Likert scale), and perception of side effects were assessed at the end of the study. **Results:** Participants who used the whitening pen either alone or in combination with whitening toothpaste showed significant improvements in tooth color and whiteness index at seven and 14 days compared to those who used whitening toothpaste alone ($p \leq 0.001$). No significant differences were found between products in overall satisfaction with treatment, perception of final tooth color, and treatment comfort. Furthermore, with the exception of the psychological influence factor after 14 days ($p \leq 0.001$), there were no significant differences in the PIDAQ questionnaire scores between the whitening products at the different time points. However, many respondents (16.6%) reported oral mucosal sensitivity and a higher percentage (27.8%) reported tooth sensitivity during whitening pen application. **Conclusion:** The combination of whitening toothpaste and whitening pen, as well as the whitening pen alone, showed effective objective color change results, but home whitening procedures did not significantly affect participants' self-perceived satisfaction or psychosocial outcomes depending on the product used.

Received: August 24, 2023

Accepted: October 12, 2023

Address for correspondence

Antonija Tadin
School of Medicine, University of Split
Department of Restorative Dental
Medicine and Endodontics
School of Medicine, University of Split
Department of Maxillofacial Surgery,
University Hospital of Split
21000 Split, Croatia
Phone: +38598609191
atadin@mefst.hr

MeSH Terms: Tooth Bleaching Agents;
Tooth Bleaching; Color; Patient
Satisfaction; Toothpastes
Author Keywords: Color Measurement;
Patient Satisfaction; Side Effects;
Tooth Whitening; Toothpaste;
Whitening Pen

Antonija Tadin, ORCID ID: 0000-0002-5365-9816
Sara Galic, ORCID ID: 0009-0004-4994-136X

Lidia Gavic, ORCID ID: 0000-0003-2882-934X

Introduction

High esthetic expectations of patients and the desire for white teeth have led to an increasing number of teeth whitening procedures being performed in dental offices. In addition to in-office whitening techniques supervised by dentists, there is a growing market for teeth whitening products that promise quick and convenient whitening at home. Various products are available for home whitening, including toothpastes, rinses, flosses, toothbrushes, gums, trays, strips, and

Uvod

Sve veća estetska očekivanja pacijenata i želja za bjeljim zubima rezultirali su sve češćim tretmanima izbjeljivanja u stomatološkim ordinacijama. Osim tretmana koje obavljaju stomatolozi, na tržištu je sve više proizvoda za kućno izbjeljivanje koji obećavaju brze i praktične rezultate. Takvi proizvodi obuhvaćaju različite opcije kao što su paste za zube, sredstva za ispiranje, zubni konac, četkice za zube, žvakaće gume, trake i gelovi (1 – 7). Zubne paste za izbjeljivanje među naj-

gels (1-7). Toothpaste is the most commonly used commercial product which can contain either various active ingredients such as abrasives, adsorbent particles, peroxides, enzymes, or optical agents. The primary whitening agents in toothpaste are usually abrasives such as CaCO_3 , SiO_2 , and Al_2O_3 . Dental floss contains the abrasive silica as a whitening agent and is used to remove pigmentation from between teeth. Rinses usually contain low concentrations of hydrogen peroxide (1.5%). Chewing gums with bleaching effect contain abrasives, and their bleaching effect is attributed to the removal of surface discoloration. However, long-term use of such chewing gums may cause damage to the tooth surface. Another method available on the market is bleaching with universal trays, where the gel is applied in the tray which is worn for few hours a day. Some packages come with a small light (LED) that helps activate the gel. Bleaching strips contain low concentrations of hydrogen peroxide (5-14%). Bleaching gels, on the other hand, contain hydrogen peroxide or urea peroxide as bleaching agents and are often available in the form of a pen that is applied to the tooth surface with a small brush (1, 7, 8).

However, the actual efficacy of these over-the-counter tooth whitening agents remains questionable and controversial. Numerous studies have demonstrated the efficacy of whitening toothpastes and pens containing whitening agents compared to conventional toothpastes (1,9). However, there is a lack of comparative studies showing which preparations, or their combination, are most effective in achieving the desired results (2-6).

Improper use of tooth whitening agents is associated with the occurrence of undesirable effects and sensations, such as excessive wear of dental tissues, irritation of periodontal and soft tissues, tooth sensitivity, cervical root resorption, crown fractures, effects on restorative materials (10). The extent of damage is influenced by factors such as the quality and concentration of the bleaching agent, the duration of application, the individual's response to the procedure, the bleaching technique used, and the presence of pre-existing conditions such as dentin hypersensitivity, abrasion/erosion, cervical caries, and existing dental restorations (10-13).

Quantitative analysis of tooth color changes and stability are essential for assessing the efficacy and effectiveness of the whitening technique (14, 15). Traditional color-measurement instruments such as spectrophotometers and colorimeters, as well as newer digital cameras, are utilized for objective assessment of color changes. These tools enable precise measurement and evaluation of color alterations. In dentistry, the most commonly used formulas for assessing the difference in color and whitening effect are as follows: CIELAB (ΔE_{ab}), CIEDE2000 (ΔE_{00}) and Whiteness Index (WID). By employing these formulas, dentists and researchers can objectively measure and compare color changes in dental treatments, particularly teeth whitening procedures, thus ensuring a standardized approach to color evaluation (16-18). However, self-reported outcomes, such as satisfaction with dental esthetics and the impact on self-esteem and social behavior, are also crucial factors to consider. Combining both quantitative and self-reported data provides a comprehensive understand-

čće su korištenim komercijalnim proizvodima, a njihovi sastojci mogu biti abrazivi, čestice adsorbensa, peroksidi, enzimi i optički agensi. Glavni sastojci za izbjeljivanje u tim pastama obično su abrazivi poput kalcijeva karbonata (CaCO_3), silicijeva dioksida (SiO_2) i aluminijska oksida (Al_2O_3). U koncu za izbjeljivanje također je abrazivni silicijev dioksid i koristi se za uklanjanje pigmentacija između zuba. Sredstva za ispiranje obično sadržavaju nisku koncentraciju vodikova peroksida (1,5 %). Žvakaće gume za izbjeljivanje sadržavaju abrazive, a njihov učinak povezan je s uklanjanjem površinskih promjena boje. Važno je napomenuti da njihova dugotrajna uporaba može oštetiti površinu zuba. Još jedna dostupna metoda jest izbjeljivanje putem prilagođenih udlaga i u tom se slučaju gel nanosi u udlage koje se nose nekoliko sati na dan. Neki od tih setova proizvode se s malom svjetiljkom (LED) koje pomaže aktivirati gel. Trake za izbjeljivanje sadržavaju nisku koncentraciju vodikova peroksida (5 – 14 %). Gelovi za izbjeljivanje, pak, sadržavaju ili vodikov peroksid ili urea-peroksid kao aktivne sastojke i često se prodaju u obliku olovaka koje se koriste za nanošenje na površinu zuba malim četkicama (1, 7, 8).

Unatoč dostupnosti proizvoda za kućno izbjeljivanje zuba, njihova stvarna učinkovitost i dalje je pitanje otvoreno za raspravu. Istraživanja su pokazala da proizvodi poput pasta za zube i olovaka sa sredstvima za izbjeljivanje mogu vidljivo promijeniti boju zuba u usporedbi s tradicionalnim pastama za zube (1, 9). No nedostaje usporedba koja bi pokazala kojim se pripravcima ili njihovim kombinacijama postižu najbolji rezultati (2 – 6).

Treba također napomenuti da nepravilna uporaba tih sredstava za izbjeljivanje zuba može prouzročiti neželjene učinke i senzacije, uključujući prekomjerno trošenje zubnih tkiva, iritaciju gingive i mekih tkiva, osjetljivost zuba, resorpciju korijena, pucanje krune zuba i oštećenje restaurativnih materijala (10). Koliko se često pojavljuju ti problemi ovisi o čimbenicima kao što su kvaliteta i koncentracija sredstva za izbjeljivanje, trajanje primjene, osjetljivost pojedinca na tretman, korištena tehnika izbjeljivanja te postojeće stanje kao što su preosjetljivost dentina, abrazija/erozija, karijes u području zubnog vrata i zubne restauracije (10 – 13).

Važno je istaknuti da je kvantitativna analiza promjena i stabilnosti boje zuba ključna za procjenu učinkovitosti tretmana izbjeljivanja (14, 15). Tradicionalni instrumenti za mjerenje boje poput spektrofotometra i kolorimetra te noviji digitalni fotoaparati, koriste se za objektivnu analizu promjena boje. Ti alati omogućuju precizno mjerenje i procjenu promjena boje. U stomatologiji se često koriste različite formule za procjenu razlike u boji i učinka izbjeljivanja, uključujući CIELAB (ΔE_{ab}), CIEDE2000 (ΔE_{00}) i indeks bjeline (WID). Koristeći ove formule, stomatolozi i istraživači mogu objektivno izmjeriti i usporediti promjene boje tijekom tretmana, osobito postupaka izbjeljivanja zubi, čime se osigurava standardizirani pristup procjeni boje (16-18). Kombinacija kvantitativnih podataka s podatcima o samoprocjeni omogućuje sveobuhvatno razumijevanje uspjeha postupka izbjeljivanja i njegova ukupnog utjecaja na pacijenta (14, 19). Dosad su provedena različita istraživanja čiji su autori ispitali psihosocijalne efekte izbjeljivanja zuba, ali i dalje nije ja-

ing of the success of the whitening procedure and its overall influence on the patient's well-being (14, 19). So far, few studies have examined the psychosocial effect of bleaching, and it remains unclear whether bleaching can affect patients' psychology or social relationships (15, 19, 20-22).

Therefore, the primary objective of this study was to evaluate the efficacy of different home whitening products and their impact on patients' psychosocial well-being, as measured by the Psychosocial Impact of Dental Aesthetics Questionnaire (PIDAQ). The second objective of the study was to assess patients' self-perceptions of satisfaction with treatment and all side effects associated with the use of over-the-counter tooth whitening products. The null hypothesis was that home tooth whitening would have no effect on patients' psychosocial well-being or their self-perception of treatment satisfaction and that there would be no whitening effect and no differences in whitening efficacy between the products tested.

Materials and methods

This prospective study was conducted among the patients of the Department for Restorative Dental Medicine and Endodontics, Study of Dental Medicine, University of Split, Croatia, between January and April 2020. The study was carried out in full accordance with ethical principles, including the World Medical Association Declaration of Helsinki (version 2008). It was approved by the Ethical Committee of the University of Split School Of Medicine, Split, Croatia. The study was performed following the Consolidated Standards of Reporting Trials guidelines (CONSORT). Participation was voluntary, anonymous, and without compensation, and all participants were informed about the background and the aim of the study. Prior to inclusion in the investigation, all participants provided their informed consent in writing.

Participants and materials

This study comprised a total of 56 patients, including 18 (32.1%) men and 38 (67.8%) women, with an age range of 20 to 41 years old (mean age: 24.49 ± 5.60). The inclusion criteria were as follows: intact upper anterior sextant teeth (teeth 13, 12, 11, 21, 22, 23), good general and oral health, absence of caries, periodontal disease, or dentinal hypersensitivity.

The study excluded individuals with damage to the oral mucosa, those allergic to specific ingredients of toothpastes and whitening agents, pregnant women, nursing mothers, and minors. Subjects with stained tetracycline teeth, dental fluorosis, and intrinsic causes of tooth discoloration, as well as those with developmental and acquired defects on their teeth, fixed prosthetic works, or orthodontic braces were also excluded. Furthermore, the study did not include subjects who had previously undergone teeth whitening procedures. Comprehensive medical and dental histories were obtained from each participant. Additionally, a structured questionnaire specifically designed for this study was administered, wherein all participants provided responses related to various factors: demographic factors (age and gender), lifestyle habits (smoking habit) and eating habits (consumption of coffee and tea).

sno kako izbjeljivanje može utjecati na psihološko stanje pacijenata ili njihove socijalne interakcije (15, 19, 20 – 22).

S obzirom na navedeno, glavna svrha ovog istraživanja bila je ocijeniti učinkovitost različitih komercijalnih proizvoda za izbjeljivanje zuba i njihov utjecaj na psihosocijalno blagostanje pacijenata, što je mjereno upitnikom psihosocijalnog utjecaja dentalne estetike (PIDAQ). Uz to, kao sekundarni cilj, procjenjivalo se pacijentovo zadovoljstvo tretmanom te bilježile eventualne nuspojave povezane s upotrebom proizvoda za izbjeljivanje zuba. Nulta hipoteza ovog istraživanja bila je da komercijalna sredstva za izbjeljivanje zuba neće znatno utjecati na psihosocijalno blagostanje pacijenata, ni na njihovo zadovoljstvo tretmanom. Također nismo očekivali značajne razlike u učinkovitosti izbjeljivanja između različitih testiranih proizvoda.

Materijal i metode

Ova prospektivna studija provedena je među pacijentima Katedre za restaurativnu dentalnu medicinu i endodonciju Studija dentalne medicine Sveučilišta u Splitu (Hrvatska) između siječnja i travnja 2020. Tijekom istraživanja u cijelosti su se poštovala etička načela, uključujući Helsinšku deklaraciju (verzija 2008.). Odobrilo ju je Etičko povjerenstvo Medicinskog fakulteta Sveučilišta u Splitu. Studija je provedena prema smjernicama Konsolidiranih standarda izvješćivanja o kliničkim ispitivanjima (CONSORT). Sudjelovanje je bilo dobrovoljno, anonimno i bez naknade, a svi sudionici bili su obaviješteni o cilju istraživanja. Prije uključivanja u istraživanje svi su potpisali informirani pristanak.

Ispitanici i materijali

Ovo istraživanje provedeno je na ukupno 56 pacijenata – 18 (32,1 %) muškaraca i 38 (67,8 %) žena u dobi od 20 do 41 godine (srednja dob $24,49 \pm 5,60$). Kriteriji za uključivanje bili su sljedeći: intaktni gornji prednji sektanti (zubi 13, 12, 11, 21, 22, 23), dobro opće i oralno zdravlje te zubi bez karijesa, parodontne bolesti ili dentinske preosjetljivosti.

U studiju nisu bili uključeni ispitanici s oštećenjem oralne sluznice, alergični na specifične sastojke pasta za zube i sredstava za izbjeljivanje, trudnice, dojilje i maloljetne osobe. Nisu mogli sudjelovati ni oni sa zubima obojenima tetraciklinom, zubnom fluorozom i intrinzičnim uzrocima obojenja zuba te s razvojnim i stečenim defektima na zubima, fiksnim protetičkim radovima ili ortodontskim aparatima. Nadalje, nisu obuhvaćeni ispitanici koji su već bili podvrgnuti zahvatima izbjeljivanja zuba. Od svakog sudionika dobivena je iscrpna medicinska i stomatološka anamneza. Dodatno je primijenjen strukturirani upitnik posebno izrađen za ovu studiju koji je uključivao pitanja vezana za demografske čimbenike (dob i spol) te životne navike (pušenje) i prehranu (konzumacija kave i čaja).

Analizom snage ovisnoga t-testa (razlika u svjetlini zuba – L^* prije i poslije nanošenja kombinacije zubne paste i olovke) s pomoću sljedećih parametara: razina značajnosti α

By analyzing the power of the dependent t-test (difference in tooth brightness - L^* before and after applying the combination of toothpaste and pencil) using the following parameters: significance level $\alpha = 0.05$, equal number of subjects in all groups, and effect size Cohen's $d = 1.19$ (based on the obtained results), it was determined that at least 10 subjects per group were required to achieve an 80% power of the test. The sample size was increased to 20 subjects in order to avoid their potential loss during the duration of the study.

Subjects were randomly divided into three groups depending on the tooth whitening agent used following a block randomization procedure using computer software. The first group ($n = 19$) used toothpaste with whitening effect Miradent Mirawhite Whitening Toothpaste Gel (Hager & Werken GmbH & Co. KG, Duisburg, Germany). The second group ($n = 18$) used Miradent Mirawhite Shine Gel – tooth whitening pen (Hager & Werken GmbH & Co. KG, Duisburg, Germany) and a commercial toothpaste without whitening effect Colgate Cavity Protection (Colgate-Palmolive, New York, USA). While the third group ($n = 19$) used toothpaste and whitening pen at the same time, Miradent Mirawhite Whitening Toothpaste Gel and Miradent Mirawhite Shine Gel (Hager & Werken GmbH & Co. KG, Duisburg, Germany). All subjects used the same toothbrush during the study – Colgate SlimSoft (Colgate-Palmolive, New York, USA). The composition of the preparations used is shown in Table 1.

Each participant received detailed instructions on oral hygiene and how to use the assigned whitening products. They were instructed to use the designated whitening agent and toothbrush for duration of 14 days. The toothpaste was to be used twice daily, in the morning and evening, for three minutes using the Bass method of brushing. The recommended amount of toothpaste was approximately 1 g (≈ 2 cm). Regarding the whitening pen, participants were instructed to apply it twice daily to a dry tooth surface, in the morning and evening, for 60 seconds. Subsequently, they were advised to rinse the gel off with water. Following the use of the pen, it was strongly advised not to eat or drink anything for the following 30 minutes. Throughout the study, the participants were explicitly instructed not to use any other means of maintaining oral hygiene and whitening agent apart from those products assigned to them for the whitening procedure.

$= 0,05$, jednak broj ispitanika u svim skupinama i učinak veličina Cohen's $d = 1,19$ (temeljem dobivenih rezultata), utvrđeno je da je za postizanje 80 % snage testa potrebno najmanje 10 ispitanika u skupini. Veličina uzorka povećana je na 20 ispitanika da bi se izbjegao njihov potencijalni odlazak tijekom trajanja studije.

Ispitanici su nasumično podijeljeni u tri skupine, ovisno o sredstvu korištenom za izbjeljivanje zuba nakon postupka slučajnog odabira s pomoću računalnog softvera. Prva skupina ($n = 19$) koristila se pastom za zube s učinkom izbjeljivanja Miradent Mirawhite Whitening Toothpaste Gel (Hager & Werken GmbH & Co. KG, Duisburg, Njemačka). Druga skupina ($n = 18$) upotrebljavala je Miradent Mirawhite Shine Gel – olovku za izbjeljivanje zuba (Hager & Werken GmbH & Co. KG, Duisburg, Njemačka) i komercijalnu pastu za zube bez učinka izbjeljivanja Colgate Cavity Protection (Colgate-Palmolive, New York, SAD). Treća se skupina ($n = 19$) koristila istodobno zubnom pastom za izbjeljivanje i olovkom za izbjeljivanje Miradent Mirawhite Whitening Toothpaste Gel i Miradent Mirawhite Shine Gel (Hager & Werken GmbH & Co. KG, Duisburg, Njemačka). Svi su se ispitanici tijekom istraživanja koristili jednakom četkicom za zube – Colgate SlimSoft (Colgate-Palmolive, New York, SAD). Sastav ispitivanih pripravaka prikazan je u tablici 1.

Svaki sudionik dobio je jasne upute o oralnoj higijeni i korištenju dodijeljenih proizvoda za izbjeljivanje. Rečeno im je da se koriste ispitivanim sredstvom za izbjeljivanje i četkicom za zube 14 dana. Zubnu pastu trebalo je upotrebljavati dva puta na dan – ujutro i navečer po tri minute korištenjem Bassove metode četkanja. Preporučena količina paste bila je približno 1 g (≈ 2 cm). Kad je riječ o olovki za izbjeljivanje, sudionici su dobili upute da je nanose dva puta na dan na suhu površinu zuba – ujutro i navečer tijekom 60 sekunda. Nakon toga im je savjetovano da gel isperu vodom. Poslije upotrebe olovke strogo se tražilo da sljedećih 30 minuta ništa ne jedu i ne piju. Tijekom istraživanja sudionici su bili izričito upozoreni da se ne koriste nikakvim drugim sredstvima za održavanje oralne higijene i izbjeljivanje, osim onih proizvoda koji su im dodijeljeni za postupak izbjeljivanja.

Table 1 Whitening products used in research
Tablica 1. Sredstva za izbjeljivanje korištena u radu

Whitening product • Proizvod	Manufacturer • Tvrtka	Type • Vrsta	Ingredients • Sastav
Miradent Mirawhite Whitening Toothpaste Gel	Hager & Werken GmbH & Co. KG, Duisburg, Germany • Njemačka	Toothpaste • Zubna pasta	Water, Sorbitol, Hydrated Silica, Propylene Glycol, Xylitol, Penta Sodium Triphosphate, Disodium Pyrophosphate, Tetracodium Pyrophosphate, Sodium C14-16 Olefin Sulfonate, Aroma, Fluidine, Ksinija, CI 42090, CI 77891 • Voda, sorbitol, hidratizirani silicijev dioksid, propilen-glikol, ksilitol, pentanatrijev trifosfat, dinatrijev pirofosfat, tetrakalijev pirofosfat, natrij C14-16 olefin- sulfonat, aroma, ksantanska guma, natrijev fluorid, natrijev saharin, tinjac, CI 42090, CI 77891
Miradent Mira White Shine Gel	Hager & Werken GmbH & Co. KG, Duisburg, Germany • Njemačka	Pen • Olovka	Water, Glycerin, Silica, Sodium gluconate, Sodium citrate, Sodium chloride, Phthalimido peroxy caproic acid (PAP), Xanthan gum, Sodium methylparaben, Cellulose gum, Aroma • Voda, glicerol, silika, natrijev glukonat, natrijev citrat, natrijev klorid, ftalimidoperoksikaproinska kiselina (PAP), ksantanska guma, natrijev metilparaben, celulozna guma, aroma

Tooth color measurements

A Vita Easyshade digital spectrophotometer (VITA Easyshade V, Vita Zahnfabrik, Bad Sackingen, Germany) was used to determine tooth color. Color assessment was performed in three time points: (T0) baseline – before the use of the tested teeth whitening agents, (T1) seven and (T2) 14 days after the commencement of using tested whitening. Using the average measurement method, three measurements were performed for each subject and each sampling time on the central and lateral incisors and canines of the upper jaw (13, 12, 11, 21, 22, 23; n = 6) on the middle third of the labial surface of the tooth. The average of these three values was used as a measured value for statistical analysis. Between each measurement, the sensor tip was removed from the tooth surface, calibrated, and repositioned. The color was determined using the CIELab color space (L*, a*, b* values). The color reading was performed in the middle third of the tooth's labial surface, in the same environment and with the same lighting conditions.

The color change between measurements in each group was estimated using the following values:

$$\Delta E_{ab}^* = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}, \Delta E_{00} = [(\Delta L'/K_1 S_L)^2 + (\Delta C^*/K_C S_C)^2 + (\Delta H'/K_H S_H)^2 + RT(\Delta C^*/S_C^* S_H^*)(\Delta H'/S_C^* S_H^*)]^{1/2}$$

i WID = 0,511L* - 2,324a* - 1,1b* [22, 23, 17, 18].

Long-term use and monitoring of tooth color change as assessment of tooth color stability after the use of the tested agents could not be performed due to the epidemic of COVID-19 disease.

Assessment of participants' satisfaction with the treatment, esthetic self-perceptions and undesirable and adverse effects

At the end of the study (14 days after starting the use of the whitening agent), the participants completed a questionnaire to assess their satisfaction with the treatment. They rated tooth color, treatment duration, treatment comfort, and overall satisfaction using a Likert scale ranging from 1 to 5 (1 - not satisfied at all, 5 - I am completely satisfied).

Additionally, at the end of the study, the participants provided feedback on the sensations they experienced during the treatment. They were asked about sensations such as burning, irritation, tooth sensitivity, taste, texture, dry mouth, presence of ulcerations (peeling, burning of the mucous membranes), and the perceived whitening effect. The responses to these sensations were categorical (yes, no, I don't know). The questionnaire also included questions about the participants' intentions regarding repeating the treatment and recommending it to their relatives and friends, which were answered categorically (yes, no, I don't know).

Questionnaires on treatment satisfaction and the sensations experienced during the use of whitening agents were adapted from similar research conducted on the topic of teeth whitening and the use of different types of toothpaste (4, 24-26).

To evaluate the psychosocial aspect of the respondents', a questionnaire on the psychosocial impact of dental esthetics (PIDAQ) was used (19, 21). The PIDAQ questionnaire comprised a total of 23 questions, which were divided into four

Mjerenje boje zuba

Za određivanje boje zuba korišten je digitalni spektrofotometar Vita Easyshade (VITA Easyshade V, Vita Zahnfabrik, Bad Sackingen, Njemačka). Procjena je provedena u trima vremenskim točkama: (T0) početna vrijednost – prije upotrebe testiranih sredstava za izbjeljivanje zuba, (T1) sedam i (T2) 14 dana poslije početka korištenja testiranog komercijalnog pripravka. Metodom prosječnog mjerenja provedena su tri mjerenja za svakog ispitanika i svako vrijeme uzorkovanja na središnjim i bočnim sjekutićima i očnjacima gornje čeljusti (13, 12, 11, 21, 22, 23; n = 6) u srednjoj trećini labijalne površine zuba. Prosjek tih triju vrijednosti korišten je kao izmjerena vrijednost za statističku analizu. Između svakog mjerenja vrh senzora uklonjen je s površine zuba, kalibriran i ponovno postavljen. Boja je određena s pomoću prostora boja CIELab. L*, a*, b* vrijednosti. Očitavanje boje obavljeno je na srednjoj trećini labijalne površine zuba, u istom okruženju i pri jednakim uvjetima osvjetljenja.

Promjena boje između mjerenja u svakoj skupini procijenjena je korištenjem vrijednosti:

$$\Delta E_{ab}^* = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}, \Delta E_{00} = [(\Delta L'/K_1 S_L)^2 + (\Delta C^*/K_C S_C)^2 + (\Delta H'/K_H S_H)^2 + RT(\Delta C^*/S_C^* S_H^*)(\Delta H'/S_C^* S_H^*)]^{1/2}$$

i WID = 0,511L* - 2,324a* - 1,1b* [22, 23, 17, 18].

Dulje korištenje i praćenje promjena boje zuba te procjena njezine postojanosti poslije primjene ispitivanih sredstava nije bilo moguće provesti zbog epidemije bolesti COVID-19.

Procjena zadovoljstva sudionika tretmanom, estetskim samopoimanjem te nepoželjnim nuspojavama

Na kraju istraživanja (14 dana poslije početka korištenja sredstava za izbjeljivanje), sudionici su ispunili upitnik kako bi procijenili svoje zadovoljstvo tretmanom. Ocjenjivali su boju zuba, trajanje i udobnost tretmana te sveukupno zadovoljstvo s pomoću Likertove ljestvice u rasponu od 1 do 5 (1 – uopće nisam zadovoljan, 5 – potpuno sam zadovoljan).

Uz to, na kraju studije sudionici su dali povratne informacije o senzacijama koje su doživjeli tijekom tretmana. Pitanja su bila o pojavama kao što su peckanje, iritacija, osjetljivost zuba, promjena okusa i teksture, suha usta, ulceracije (ljuštenje, pečenje sluznice) i percipirani učinak izbjeljivanja. Odgovori su bili kategorični (da, ne, ne znam). Upitnik je sadržavao i pitanja o namjerama sudionika da ponove tretman i preporuča ga rodbini i prijateljima, a odgovori su također bili kategorični (da, ne, ne znam).

Upitnici o zadovoljstvu tretmanom i senzacijama tijekom korištenja sredstava za izbjeljivanje prilagođeni su prema sličnim istraživanjima o izbjeljivanju zuba i korištenju različitih vrsta zubnih pasti (4, 24 – 26).

Za procjenu psihosocijalnog aspekta ispitanika korišten je upitnik o psihosocijalnom utjecaju dentalne estetike (PIDAQ) (19, 21). Sastojao se od ukupno 23 pitanja podijeljena u četiri kategorije: estetski problemi, društveni utjecaj, psihološki utjecaj i dentalno samopouzdanje. Svaka stavka u upitniku ocijenjena je korištenjem Likertove ljestvice u rasponu od 0 do 4, pri čemu 0 označava „nema nikakva utjecaja”, a 4 znači „maksimalni utjecaj”. Tvrdnje vezane za dentalno sa-

categories: esthetic concerns, social impact, psychological impact, and dental self-confidence. Each item in the PIDAQ questionnaire was rated using the Likert scale, ranging from 0 to 4, with 0 indicating "no impact at all" and 4 indicating "maximum impact." Claims related to dental self-confidence were affirmative, while others were negative. The questionnaires were administered at three time points: at the beginning of the study, after seven days, and after 14 days after the commencement of using the whitening agent.

Statistical data processing

The collected data were entered into a pre-existing Microsoft Excel 2007 table (Microsoft Corporation, Redmond, Washington, USA) and coded for further analysis using the statistical package for social sciences (SPSS, version 26, IBM Corp, Armonk, New York, USA). The initial analysis of the results involved using descriptive statistics. Continuous variables were presented as either the mean and standard deviation or the median and interquartile range, while categorical variables were expressed as numbers and percentages. The Shapiro-Wilks test was used to assess the normality of the distribution of quantitative variables. Differences between groups and within the group were compared using the Kruskal-Wallis one-way analysis of variance (ANOVA) and Friedman two-way ANOVA. Differences between categorical variables were evaluated using the χ^2 test and Fisher test as appropriate. Furthermore, a linear regression analysis was performed to examine the relationship between respondents' satisfaction with the treatment and whitening effect and their demographic characteristics, tooth color measures, and aesthetic concerns, social and psychological impact, and dental confidence. All statistical analyses were performed with a significance level set at $p < 0.05$.

Results

The flow diagram of the study with parallel randomized three groups (that is, enrollment, intervention allocation, follow-up, and data analysis) is presented in Figure 1.

The study involved 56 subjects divided into three groups depending on the agent used. No statistically significant difference in gender ($p=0.836$) and age ($p=0.116$) was observed among different groups of respondents (Table 2).

Table 3 shows the median values of total shade change (ΔE_{ab} and ΔE_{00}) and whiteness index (ΔWID) for each eval-

mopouzdanje bile su afirmativne, a druge su bile negativne. Upitnici su primjenjivani u trima vremenskim točkama: na početku istraživanja, 7 dana poslije i 14 dana poslije početka korištenja sredstva za izbjeljivanje.

Statistička obrada podataka

Prikupljeni podatci uneseni su u već postojeću tablicu Microsoft Excel 2007 (Microsoft Corporation, Redmond, Washington, SAD) i kodirani za daljnju analizu korištenjem statističkog paketa za društvene znanosti (SPSS, verzija 26, IBM Corp, Armonk, New York, SAD). Početna analiza rezultata uključivala je korištenje deskriptivne statistike. Kontinuirane varijable prikazane su ili kao srednja vrijednost i standardna devijacija ili kao medijan i interkvartilni raspon, a kategoričke varijable izražene su kao brojevi i postotci. Za procjenu normalnosti distribucije kvantitativnih varijabli korišten je Shapiro-Wilksov test. Razlike između skupina i unutar skupine uspoređene su korištenjem Kruskal-Wallisove jednosmjerne analize varijance (ANOVA) i Friedmanove dvosmjerne ANOVA-e. Razlike između kategoričkih varijabli procijenjene su, prema potrebi, χ^2 testom i Fisherovim testom. Nadalje, provedena je linearna regresijska analiza da bi se ispitaio odnos između zadovoljstva ispitanika tretmanom i učinkom izbjeljivanja i njihovih demografskih karakteristika, mjera boje zuba i estetskih problema, društvenog i psihološkog utjecaja i dentalnog povjerenja. Sve statističke analize obavljene su s razinom značajnosti postavljenom na $p < 0,05$.

Rezultati

Dijagram tjeka studije s trima paralelnim randomiziranim skupinama (prikupljanje pacijenata, raspodjela intervencija, praćenje i analiza podataka) nalazi se na slici 1.

U istraživanju je sudjelovalo 56 ispitanika podijeljenih u tri skupine, ovisno o korištenom sredstvu. Nije uočena statistički značajna razlika u spolu ($p = 0,836$) i dobi ($p = 0,116$) među različitim skupinama ispitanika (tablica 2.).

Tablica 3. prikazuje srednje vrijednosti ukupne promjene boje (ΔE_{ab} i ΔE_{00}) i indeksa bjeline (ΔWID) za svako razdo-

Table 2 Descriptive statistics of life habits and demographic data of respondents

Tablica 2. Deskriptivna statistika navika i demografskih podataka za različite grupe ispitanika ovisno o korištenom sredstvu s učinkom izbjeljivanja

Characteristic • Karakteristika	Whitening product • Proizvod za izbjeljivanje				
	WT	WP	WT + WP	Total	
Number of subjects • Broj ispitanika	19 (33.9%)	18 (32.1%)	19 (33.9%)	56 (100%)	
Age (years) • Dob (godine)	25.83±3.59	24.56±3.16	24.21±3.82	24.49±5.60	
Gender • Spol	Male • Muškarac	6 (31.5 %)	5 (27.7 %)	7 (36.9 %)	18 (32.1%)
	Female • Žena	13 (68.4 %)	13 (68.4 %)	12 (63.1 %)	38 (67.8%)

Values are shown as number and percentage or mean and standard deviation • Vrijednosti su prikazane kao srednja vrijednost i standardna devijacija, medijan (min/maks.) ili kao cijeli broj i postotak. Abbreviations • Skraćenice: WT – whitening toothpaste, WP – whitening pen, WT + WP – whitening toothpaste and pen. • WT – zubna pasta, WP – olovka, WT + WP – zubna pasta i olovka

1 CONSORT

TRANSPARENT REPORTING OF TRIALS

CONSORT 2010 Flow Diagram

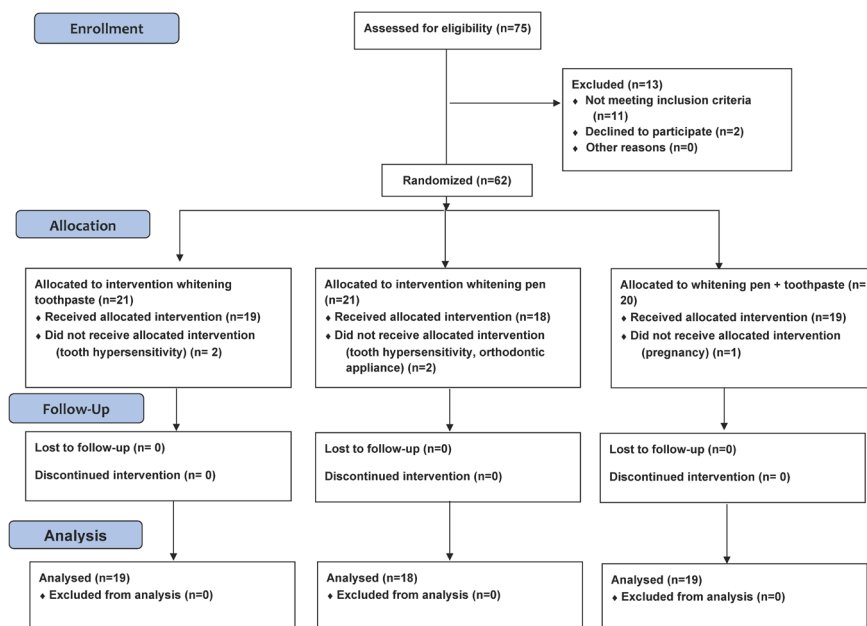


Figure 1 Flowchart of participant's recruitment and follow-up

Slika 1. Dijagram uključivanja sudionika i praćenja

Figure 2 Multiple regression analysis results - the influence of sociodemographic factors, color changes, and PIDAQ variables on satisfaction with treatment and achieved tooth color

Slika 2. Rezultati višestruke regresijske analize – utjecaj socijalno-demografskih čimbenika, promjena boje i PIDAQ varijabli na zadovoljstvo tretmanom i postignutu boju zuba

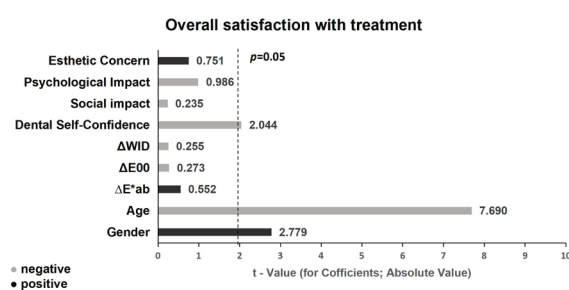
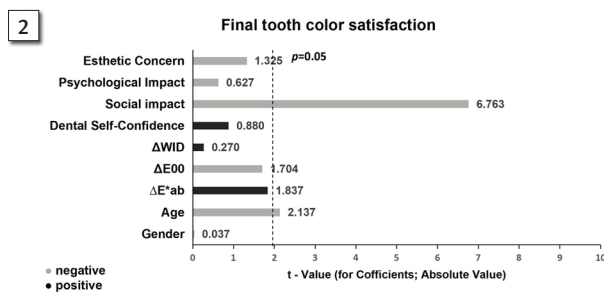


Table 3 Changes of color by ΔE_{00} , ΔE^*_{ab} , and ΔWID by the group in different periods
Tablica 3. Promjena boje ΔE_{00} , ΔE^*_{ab} i ΔWID po grupama za različita ispitivana vremena

Color measures • Parametri boje	Whitening product • Proizvod za izbjeljivanje			p-value • p-vrijednost
	WT	WP	WT+WP	
$\Delta E_{ab(T1-T0)}$	1.76 (1.00-3.13) ^{a,b,A}	3.73 (2.23-6.00) ^{a,A,C}	3.78 (2.57-5.64) ^{b,A,C}	$\leq 0.001^*$
$\Delta E_{ab(T2-T0)}$	1.97 (1.26-3.15) ^{a,b,A,B}	4.55 (2.49-6.94) ^{a,A,B}	4.27 (2.86-6.19) ^{b,A,B}	$\leq 0.001^*$
$\Delta E_{ab(T2-T1)}$	1.42 (0.81-2.25) ^B	1.58 (0.91-2.53) ^{B,C}	1.64 (0.98-2.56) ^{B,C}	0.358
p-value • p-vrijednost	$\leq 0.001^*$	$\leq 0.001^*$	$\leq 0.001^*$	
$\Delta E_{00(T1-T0)}$	1.10 (0.63-1.99) ^{a,b,A}	2.38 (1.33-4.00) ^{a,A,C}	2.55 (1.61-3.88) ^{b,A,C}	$\leq 0.001^*$
$\Delta E_{00(T2-T0)}$	1.22 (0.81-2.11) ^{a,b,A,B}	2.88 (1.58-4.41) ^{a,A,B}	2.80 (1.94-3.99) ^{b,A}	$\leq 0.001^*$
$\Delta E_{00(T2-T1)}$	1.07 (0.57-1.73) ^B	1.26 (0.70-1.93) ^{B,C}	1.28 (0.80-2.12) ^{A,C}	0.230
p-value • p-vrijednost	$\leq 0.001^*$	$\leq 0.001^*$	$\leq 0.001^*$	
$\Delta WI_{D(T1-T0)}$	0.25 (-0.62-1.39) ^{a,b,A}	2.80 (1.29-4.80) ^{a,A,C}	2.85 (0.93-4.11) ^{b,A,C}	$\leq 0.001^*$
$\Delta WI_{D(T2-T0)}$	1.17 (-0.12-2.02) ^{a,b,A,B}	3.16 (1.64-4.77) ^{a,A,B}	3.16 (1.61-4.75) ^{b,A,B}	$\leq 0.001^*$
$\Delta WI_{D(T2-T1)}$	0.44 (-0.26-1.76) ^B	0.37 (-0.65-1.08) ^{B,C}	0.32 (-0.62-1.53) ^{B,C}	0.362
p-value • p-vrijednost	$\leq 0.001^*$	$\leq 0.001^*$	$\leq 0.001^*$	

Values are shown as median and interquartile range. The same lowercase letter in a row indicates statistical significance between different teeth whitening agents and same capital letters indicate a significant difference among the evaluation periods ($p < 0.05$). • Vrijednosti su prikazane kao medijan i interkvartilni raspon. Isto malo slovo u redu označava statističku značajnost unutar pojedine grupe u različitim vremenima uzorkovanja, a isto veliko slovo u koloni označava statističku značajnost između različitih sredstava za izbjeljivanje zuba ($p \leq 0,05$). Abbreviations • Skraćenice: T0 - before treatment; T1 - 7 days after the commencement of use; T2 - 14 days after the commencement of use; WT - whitening toothpaste, WP - whitening pen, WT + WP - whitening toothpaste and pen • T0 - prije tretmana; T1 - 7 dana od početka korištenja; T2 - 14 dana od početka korištenja, WT - zubna pasta, WP - olovka, WT + WP - zubna pasta i olovka.

uation period and the bleaching agents tested. The resulting change in tooth color (ΔE^*ab , $\Delta E00$) and change in whiteness index (ΔWID) showed a clinically significant change in tooth color compared to baseline values ($p \leq 0.001$) for all bleaching agents tested at the time points evaluated (T1 and T2). A statistically significant increase in overall shade change (ΔE^*ab and $\Delta E00$) and whiteness index (ΔWID) for each evaluation time point (T1 and T2) compared to baseline values was confirmed in subjects using a bleaching pen and a combination of bleaching pen and toothpaste compared to those using bleaching toothpaste ($p \leq 0.001$).

The median and interquartile ranges of respondents' satisfaction with the whitening procedure are shown in Table 4. The only statistically significant difference was found between the whitening pen and whitening toothpaste groups in length of treatment ($p = 0.027$).

Table 5 shows the side effects experienced by the respondents when using the different teeth whitening products. Tooth sensitivity was noted by 27.8% of the respondents who used the whitening pen and by 21.1% of the respondents who used the combination of whitening toothpaste

blje ocjenjivanja i testirana sredstva za izbjeljivanje. Rezultati dobiveni promjenama boje zuba ($\Delta E^*a b$, $\Delta E00$) i promjena indeksa bjeline (ΔWID) pokazali su klinički značajnu promjenu boje zuba u usporedbi s osnovnim vrijednostima ($p \leq 0,001$) za sva sredstva za izbjeljivanje testirana u procijenjenim vremenskim točkama (T1 i T2). Statistički značajno povećanje ukupne promjene boje (ΔE^*ab i $\Delta E00$) i indeksa bjeline (ΔWID) za svaku vremensku točku ispitivanja (T1 i T2), u usporedbi s osnovnim vrijednostima, potvrđeno je kod ispitanika koji su se koristili olovkom za izbjeljivanje i kombinacijom olovke za izbjeljivanje i zubne paste u usporedbi s onima koji su upotrebljavali samo pastu za izbjeljivanje ($p \leq 0,001$).

Medijan i interkvartilni raspon zadovoljstva ispitanika postupkom izbjeljivanja prikazani su u tablici 4. Jedina statistički značajna razlika i to u duljini tretmana ($p = 0,027$) pronađena je između skupine koja se koristila olovkom za izbjeljivanje i pastom za izbjeljivanje.

U tablici 5. su nuspojave koje su ispitanici istaknuli pri korištenju različitih proizvoda za izbjeljivanje zuba. Osjetljivost zuba navelo je 27,8 % ispitanika koji su upotrebljavali

Table 4 Respondents' satisfaction with different characteristics of whitening agent and procedure
Tablica 4. Zadovoljstvo ispitanika različitim karakteristikama sredstava za izbjeljivanje i tretmanom

Characteristics • Karakteristika	Whitening product • Sredstvo za izbjeljivanje			p-value • p-vrijed.
	WT	WP	WT + WP	
Final tooth color • Završna boja zuba	4.00 (3.00-4.00)	4.00 (3.00-4.25)	4.00 (3.00-4.00)	0.632
Length of treatment • Trajanje tretmana	4.00 (3.00-4.00) ^a	5.00 (3.75-5.00) ^a	4.00 (3.00-5.00)	0.027*
Comfort during treatment • Udobnost tijekom tretmana	5.00 (4.00-5.00)	5.00 (4.00-5.00)	5.00 (3.00-5.00)	0.541
Overall satisfaction with treatment • Ukupno zadovoljstvo tretmanom	4.00 (3.00-5.00)	4.50 (4.00-5.00)	4.00 (3.00-5.00)	0.103

Values are shown as median and interquartile range. The same lowercase letter in a row indicates statistical significance between different teeth whitening agents ($p < 0.05$) • Vrijednosti su prikazane kao medijan i interkvartilni raspon. Isto malo slovo u redu označava statističku značajnost unutar pojedine grupe u različitim vremenima uzorkovanja ($p \leq 0,05$). Abbreviations • Skraćenice: T0 - before treatment; T1 - 7 days after the commencement of use; T2 - 14 days after the commencement of use; WT - whitening toothpaste, WP - whitening pen, WT + WP - whitening toothpaste and pen, WT - zubna pasta, WP - olovka, WT + WP - zubna pasta i olovka

Table 5 Adverse and undesirable side effects experienced by the respondents
Tablica 5. Štetne i nepoželjne nuspojave koje su prijavili ispitanici

Side effects • Nuspojave	Whitening product • Sredstvo za izbjeljivanje			p-value
	WT	WP	WT + WP	
Burn • Pečenje	1 (5.2 %)	1 (5.8 %)	2 (10.5 %)	0.780
Irritation • Iriracija	2 (10.5 %)	0 (0%)	2 (10.5 %)	0.316
Oral mucosa sensitivity • Osjetljivost oralne sluznice	2 (10.5 %)	3 (16.6 %)	3 (15.7 %)	0.810
Tooth sensitivity • Osjetljivost zuba	1 (5.2 %)	5 (27.8%)	4 (21.1%)	0.183
Unpleasant taste • Neugodan okus	0 (0%)	0 (0%)	2 (10.5 %)	0.133
Unpleasant texture (sandy, rough, sticky) • Neugodna tekstura (pjeskovita, gruba, ljepljiva)	1 (5.2 %)	0 (0%)	0 (0%)	0.371
Peeling, roughness of the oral mucosa (cheek, tongue, lips, gums) • Ljuštenje, hrapavost oralne sluznice (obraz, jezik, usne, zubno meso)	1 (5.2 %)	0 (0%)	2 (10.5 %)	0.361
Dry mouth, thirst • Suhoća usta, žeđ	3 (15.7 %)	1 (5.8 %)	1 (5.2 %)	0.435
Ulcers on the oral cavity / wounds • Ulceracije / ranice	0 (0 %)	2 (11.1 %)	0 (0 %)	0.112
Itching (cheek, tongue or lips) • Svrbež (obraz, jezik ili usne)	0 (0%)	0 (0 %)	0 (0 %)	n.a.
Tingling (cheek, tongue or lips) • Trnci (obraz, jezik ili usne)	2 (10.5 %)	0 (0 %)	1 (5.2 %)	0.364
Mouth taste change • Promjena okusa	1 (5.2 %)	3 (16.6 %)	0 (0 %)	0.134

Values are shown as number and percentage. * Chi-square test or Fisher's test, $df=2$; $p < 0.05$ • Vrijednosti su prikazane kao cijeli broj i postotak. * Hi-kvadrat test ili i Fisherov test, $df = 2$; $p < 0,05$. Abbreviations • Skraćenice: n.a. - non acceptable; WT - whitening toothpaste, WP - whitening pen, WT + WP - whitening toothpaste and pen • : WT - zubna pasta, WP - olovka, WT + WP - zubna pasta i olovka.

and pen. A change in taste was noted by 16.6% and oral ulcers by 11.1% of respondents who used whitening pen. The majority of respondents liked the whitening product used and would be happy to recommend it to others and use it again (84.2% - WT, 89.4% - WT + WP and 94.7% - WP; 84.2% - WT, 89.4% - WT + WP and 94.7% - WP). All subjects who used a whitening pen noticed the whitening effect on their teeth (100%), as well as 94.7% of subjects who used a combination of whitening toothpaste and a pen, while only 63.1% of subjects who used whitening toothpaste noticed the whitening effect.

All tested whitening products showed a statistically significant improvement in the psychological impact factor according to the PIDAQ scale after 14 days of usage ($p \leq 0.001$). Additionally, for the whitening pen and the combination of whitening pen and toothpaste, the significance persisted even after seven days of use ($p \leq 0.001$). However, no differences were found in the other PIDAQ dimensions when comparing the different times of use for the tested whitening products (Table 6).

The dependence of satisfaction with the whitening agent (final tooth color, overall satisfaction with the treatment) was determined using the linear regression model and presented in the form of Pareto diagrams (Figure 2). The effects of all observed demographic and lifestyle variables, as well as the PIDAQ variables that appeared as predictor variables, were observed for age ($\beta = -0.089$, $SE = 0.012$, $p \leq 0.001$), gender-female ($\beta = 0.373$, $SE = 0.174$, $p = 0.006$), and dental self-confidence ($\beta = -0.024$, $SE = 0.012$, $p = 0.042$) on overall satisfaction with treatment. On tooth color satisfaction, age ($\beta = 0.109$, $SE = 0.016$, $p = 0.033$) and social influence of PIDAQ ($\beta = -0.089$, $SE = 0.012$, $p \leq 0.001$) have a significant influence.

olovku za izbjeljivanje i 21,1 % ispitanika koji su se koristili kombinacijom paste za izbjeljivanje zuba i olovke. Promjenu okusa prijavilo je 16,6 %, sudionika, a oralne ulceracije sluznice 11,1 % koji su se koristili olovkom za izbjeljivanje zuba. Većini se svidio korišteni proizvod za izbjeljivanje i rado bi ga preporučili drugima i ponovno upotrijebili (84,2 % - WT, 89,4 % - WT + WP i 94,7 % - WP; 84,2 % - WT, 89,4 % - WT + WP i 94,7 % - WP). Svi ispitanici koji su se koristili olovkom za izbjeljivanje uočili su učinak izbjeljivanja na svojim zubima (100 %), zatim 94,7 % onih koji su upotrebljavali kombinaciju paste za izbjeljivanje i olovke te samo 63,1 % ispitanika koji su se koristili pastom za izbjeljivanje zuba.

Svi testirani proizvodi za izbjeljivanje pokazali su statistički značajno poboljšanje čimbenika psihološkog utjecaja prema ljestvici PIDAQ poslije 14 dana korištenja ($p \leq 0,001$). Osim toga, za olovku za izbjeljivanje i kombinaciju olovke za izbjeljivanje i paste za zube, značajnost je ostala čak i poslije 7 dana korištenja ($p \leq 0,001$). Međutim, nisu pronađene razlike u drugim dimenzijama PIDAQ-a pri usporedbi različitih vremena uporabe testiranih proizvoda za izbjeljivanje (tablica 6.).

Ovisnost o zadovoljstvu sredstvom za izbjeljivanje (konačna boja zuba, ukupno zadovoljstvo tretmanom) određena je linearnim regresijskim modelom i prikazana u obliku Paretova dijagrama (slika 2.). Socijalno-demografske i PIDAQ varijable postavljene su kao prediktori. Na ukupno zadovoljstvu tretmanom, kao značajna varijabla, potvrđena je dob ($\beta = -0,089$, $SE = 0,012$, $p \leq ,001$), spol – ženski ($\beta = 0,373$, $SE = 0,174$, $p = 0,006$) i dentalno samopouzdanje ($\beta = -0,024$, $SE = 0,012$, $p = 0,042$). Na zadovoljstvo bojom zuba također je znatno utjecala dob ($\beta = 0,109$, $SE = 0,016$, $p = 0,033$) te društveni utjecaj PIDAQ ($\beta = -0,089$, $SE = 0,012$, $p \leq 0,001$).

Table 6 PIDAQ results at different time points
Tablica 6. PIDAQ rezultati za različita ispitivana vremena

Whitening product • Sredstvo za izbjeljivanje	Dimension • Dimenzija	Time points • Vrijeme testiranja			
		Baseline – T0 • Početno – T0	7 days – T1 • 7 dana – T1	14 days – T2 • 14 dana – T2	p-value • p-vrijednost
WT	Dental Self-Confidence • Dentalno samopouzdanje	15.00 (8.00-18.00)	15.00 (9.00-18.00)	16.00 (10.00-21.00)	0.081
	Social impact • Socijalni utjecaj	0.00 (0.00-5.00)	0.00 (0.00-3.00)	1.00 (0.00-6.00)	0.081
	Psychological Impact • Psihološki utjecaj	5.00 (3.00-9.00) ^a	5.00 (4.00-8.00)	4.00 (3.00-8.00) ^a	$\leq 0.001^*$
	Esthetic Concern • Zabrinutost zbog estetike	0.00 (0.00-1.00)	0.00 (0.00-2.00)	0.00 (0.00-3.00)	0.693
WT + WP	Dental Self-Confidence • Dentalno samopouzdanje	12.00 (9.00-18.00)	13.00 (10.00-18.00)	12.00 (10.00-20.00)	0.339
	Social impact • Socijalni utjecaj	1.00 (0.00-5.00)	1.00 (0.00-5.00)	1.00 (0.00-3.00)	0.985
	Psychological Impact • Psihološki utjecaj	5.00 (3.00-8.00) ^{ab}	4.00 (2.00-7.00) ^b	4.00 (2.00-6.00) ^{ab}	$\leq 0.001^*$
	Esthetic Concern • Zabrinutost zbog estetike	2.00 (0.00-4.00)	2.00 (0.00-3.00)	2.00 (0.00-3.00)	0.479
WP	Dental Self-Confidence • Dentalno samopouzdanje	15.00 (13.00-19.00)	14.00 (12.00-18.00)	17.00 (12.00-19.00)	0.094
	Social impact • Socijalni utjecaj	2.50 (0.00-4.00)	2.50 (0.00-6.00)	2.50 (0.00-7.00)	0.451
	Psychological Impact • Psihološki utjecaj	8.00 (3.00-11.75) ^a	6.50 (3.00-9.00) ^c	4.00 (2.75-6.75) ^{ac}	$\leq 0.001^*$
	Esthetic Concern • Zabrinutost zbog estetike	0.50 (0.00-4.75)	1.50 (0.00-3.00)	1.00 (0.00-3.75)	0.784

Values are shown as median and interquartile range. The same lowercase letter in a row indicates statistical significance between different time points ($p < 0.05$) • Vrijednosti su prikazane kao medijan i interkvartilni raspon. Isto malo slovo u redu označava statističku značajnost u različitim vremenima uzorkovanja ($p \leq 0,05$). Abbreviations • Skraćenice: T0 - before treatment; T1 - 7 days after the commencement of use; T2 - 14 days after the commencement of use; WT - whitening toothpaste, WP - whitening pen, WT + WP - whitening toothpaste and pen. • T0 - prije tretmana; T1 - 7 dana od početka korištenja; T2 - 14 dana od početka korištenja, WT - zubna pasta, WP - olovka, WT + WP - zubna pasta i olovka

Discussion

The use of commercially available whitening products for home use, such as toothpaste, gel, pen, tape, and rinsing liquid, can serve as an alternative for correcting mild tooth stains (1). This study aimed to evaluate and compare the effectiveness of different commercially available teeth whitening over-the-counter agents (toothpaste, pen, and their combination) and to assess the satisfaction of respondents with the treatment and the achieved effect. The subjects who used the pen and a combination of toothpaste and pen experienced a significant color change (ΔE) after seven and 14 days of usage compared to those who used only whitening toothpaste. Based on the results obtained, we can conclude that the initial hypotheses were not confirmed, and the means used proved to be effective with significant differences between them.

Over-the counter whitening products typically contain lower levels of the whitening agent and are applied to the tooth with a brush, tape, or toothbrush, usually requiring application twice a day for up to two weeks. External stains on the tooth surface can be removed with some abrasive agents found in toothpaste, while internal stains can be eliminated through oxidation. The whitening toothpaste used in this study contains abrasive and chemical agents such as pyrophosphate and hydrated silicon. Pyrophosphates have a strong binding affinity and effectively remove components causing tooth color staining (18). Hydrated silicon possesses cleaning abilities and is more effective in removing stains from enamel and dentin compared to other abrasives (1). The pen used in this study contains peroxyacetic acid (PAP), which has a high oxidation potential and is crucial for the whitening process as it neutralizes the double organic bonds responsible for tooth discoloration (27). Additionally, the pen contains the active ingredient sodium chlorite which releases a small amount of chlorine dioxide in the presence of acids (28). Compared to hydrogen peroxide, PAP gel exhibits a similar whitening effect while being less harmful to enamel and oral mucosa (29).

The use of whitening agents resulted in a noticeable change in tooth color (ΔE) after seven and 14 days of use. However, the subjects who used a pen and a combination of pen and toothpaste experienced a higher color change compared to those who used toothpaste alone. Clinically significant tooth color change, as defined by $\Delta E_{ab}^* \geq 1, 2$, $\Delta WI_D \geq 0,72$, and/or $\Delta E_{00} \geq 0,8$, can be visibly noticed by human eyes and is essential in evaluating the effectiveness of whitening agents (30). Therefore, after seven days of using all tested whitening products, the changes were visible to the naked eye. However, after 14 days of use, all whitening agents showed a greater color change than that observed after seven days, with significant differences between them. Greater color changes were observed in subjects who used the whitening pen and a combination of products after seven and 14 days of use, compared to those who used whitening toothpaste alone.

The evaluation of the effect of whitening toothpastes and other home whitening agents can be conducted through

Rasprava

Upotreba komercijalno dostupnih proizvoda za izbjeljivanje za kućnu upotrebu, kao što su zubne paste, olovke, trake i tekućine za ispiranje, može poslužiti kao alternativa za korekcije blagih obojenja na zubima (1). Ovo istraživanje imalo je za cilj procijeniti i usporediti učinkovitost različitih komercijalno dostupnih sredstava za izbjeljivanje zuba (zubna pasta, olovka i njihova kombinacija) te procijeniti zadovoljstvo ispitanika tretmanom i postignutim učinkom. Ispitanici koji su se koristili olovkom i kombinacijom zubne paste i olovke postigli su znatnu promjenu boje (ΔE) 7 i 14 dana poslije korištenja, u usporedbi s onima koji su upotrebljavali samo zubnu pastu za izbjeljivanje. Na temelju dobivenih rezultata možemo zaključiti da početne hipoteze nisu potvrđene jer su se korištena sredstva pokazala učinkovitima uz znatne razlike među njima.

Proizvodi za izbjeljivanje koji se slobodno prodaju obično sadržavaju nižu razinu sredstva za izbjeljivanje i nanose se na zub aplikatorom, trakom ili četkicom za zube, što obično zahtijeva nanošenje dva puta na dan tijekom dva tjedna. Vanjske mrlje na površini zuba mogu se ukloniti nekim abrazivnim sredstvima koja se nalaze u zubnoj pasti, a unutarnje oksidacijom. Zubna pasta za izbjeljivanje korištena u ovoj studiji sadržava abrazivna i kemijska sredstva poput pirofosfata i hidratiziranog silicija. Pirofosfati imaju snažan afinitet vezanja i učinkovito uklanjaju komponente koje uzrokuju bojenje zuba (18). Hidratizirani silicij ima svojstvo čišćenja i učinkovitiji je u uklanjanju mrlja s cakline i dentina u usporedbi s drugim abrazivima (1). Olovka korištena u ovoj studiji sadržava peroksikaproinsku kiselinu (PAP) koja ima visok oksidacijski potencijal i ključna je za proces izbjeljivanja zato što neutralizira dvostruke organske veze odgovorne za promjenu boje zuba (27). Dodatno, olovka sadržava i aktivni sastojak – to je natrijev klorit koji oslobađa malu količinu klorova dioksida u prisutnosti kiselina (28). U usporedbi s vodikovim peroksidom, PAP gel pokazuje sličan učinak izbjeljivanja, a manje oštećuje caklinu i oralnu sluznicu (29).

Korištenje sredstava za izbjeljivanje u ovom istraživanju rezultiralo je primjetnom promjenom boje zuba (ΔE) 7 i 14 dana poslije korištenja. No ispitanici koji su se koristili olovkom i kombinacijom olovke i zubne paste s učinkom izbjeljivanja postigli su veću promjenu boje u usporedbi s onima koji su upotrebljavali samo zubnu pastu s učinkom izbjeljivanja. Klinički značajna promjena boje zuba, definirana s pomoću $\Delta E_{ab}^* \geq 1, 2$, $\Delta WI_D \geq 0,72$ i/ili $\Delta E_{00} \geq 0,8$, može se jasno primijetiti očima i ključna je u procjeni učinkovitosti sredstava za izbjeljivanje [30]. Zato su 7 dana poslije korištenja svih testiranih proizvoda za izbjeljivanje promjene bile vidljive golim okom. No poslije 14 dana sva sredstva za izbjeljivanje pokazala su promjenu boje veću od one uočene nakon 7 dana, sa znatnim razlikama među njima. Veće promjene boje uočene su kod ispitanika koji su se koristili olovkom za izbjeljivanje i kombinacijom proizvoda poslije 7 i 14 dana primjene, u usporedbi s onima koji su upotrebljavali samo zubnu pastu za izbjeljivanje.

Procjena učinka pasta za zube za izbjeljivanje i drugih sredstava za izbjeljivanje za kućnu upotrebu može se obaviti

in vitro studies using extracted teeth or through *in vivo* clinical trials. However, the available literature presents contradictory efficacy results from *in vitro* studies. For instance, one study (31) confirmed the whitening effect of several commercially available whitening toothpastes in India after four weeks of use. Similarly, Vaz et al. (32) demonstrated that all whitening toothpastes achieved effective tooth whitening compared to toothpaste without additional whitening agents. According to their findings, the best bleaching effect was achieved with microbeads, followed by hydrogen peroxide and blue covarine. They have also emphasized that continuous use of these products is necessary to achieve a more pronounced and better whitening effect.

It is important to note that while *in vitro* studies provide valuable insights into the potential effects of whitening agents on extracted teeth, the outcomes might not perfectly mirror real-world situations and clinical effectiveness. Thus, the findings of *in vitro* studies should be considered in conjunction with results of *in vivo* clinical trials to obtain a comprehensive understanding of the actual impact of whitening agents on tooth color in practical usage scenarios (33). There have been several clinical studies examining the clinical effect of whitening toothpastes [34-38] and whitening pens (29). Horn et al. (37) observed the whitening effect of four toothpastes after 15 days of use. However, they did not observe that the use of any whitening toothpastes led to a visible change in tooth color. Similarly, Pintado-Palomino et al. (38) found no difference in color change after four weeks of using two toothpastes with a whitening effect compared to conventional toothpaste without any effect. In contrast, other studies in the literature have confirmed the effectiveness of various whitening toothpastes (39, 40). Bizhang et al. (41) evaluated the effect of a gel preparation containing peroxyacetic acid and found a significant effect after only one use. In this study all subjects who used a pen noticed the whitening effect on their teeth (100%), likewise 94.7% of subjects who used a combination of toothpaste and pen. Respondents were more satisfied with the results obtained after using the pen and the combination of pen and toothpaste than with toothpaste alone ($p < 0.001$).

The most common unfavorable side effects of the use of teeth whitening products are dentinal hypersensitivity and gingival irritation. Fiorillo et al. (42) have stated that teeth whitening procedures should be avoided in patients who already suffer from dental hypersensitivity. Unfortunately, the effect on the hard tissues of the teeth can contribute to the development of hypersensitivity. However, they have also emphasized that the esthetic effect of teeth whitening is always present, whether it is performed at home or by professional treatments. They believe that improving a smile, in this case by teeth whitening, also enhances the quality of life for patients. In this study, 27.8% of respondents who used the pen complained of tooth sensitivity during use. Likewise, 21.1% of respondents who used a combination of toothpaste and pen complained of tooth sensitivity. Only 5.2% of respondents who used toothpaste alone complained of tooth sensitivity. Burning, irritation, and tenderness within the oral cavity were experienced by less than 10% of the subjects, re-

na temelju studije *in vitro* na izvađenim zubima ili kliničkih ispitivanja *in vivo*. No u dostupnoj literaturi kontradiktorni su rezultati o učinkovitosti studija *in vitro*. Na primjer, u jednoj je studiji (31) potvrđen učinak izbjeljivanja nekoliko komercijalno dostupnih pasta za izbjeljivanje zuba u Indiji poslije 4 tjedna korištenja. Vaz i suradnici (32) pokazali su slično, naime, da se sa svim zubnim pastama za izbjeljivanje može postići učinkovito izbjeljivanje zuba u usporedbi s pastama za zube bez dodatnih sredstava za izbjeljivanje. Prema njihovim nalazima najbolji učinak izbjeljivanja postignut je mikrozrnima, zatim vodikovim peroksidom i plavim kovarinom. Također ističu da je kontinuirana uporaba tih proizvoda nužna za postizanje izraženijeg i boljeg učinka izbjeljivanja.

Važno je napomenuti da, iako studije *in vitro* omogućuju važan uvid u potencijalne učinke sredstava za izbjeljivanje na izvađene zube, rezultati možda neće savršeno odražavati situacije iz stvarnog života i kliničku učinkovitost. Zato bi se nalazi iz studija *in vitro* trebali razmotriti zajedno s rezultatima kliničkih ispitivanja *in vivo* kako bi se dobilo sveobuhvatno razumijevanje stvarnog utjecaja sredstava za izbjeljivanje na boju zuba u praktičnoj uporabi (33). Provedeno je nekoliko kliničkih studija u kojima su autori ispitali klinički učinak zubnih pasta za izbjeljivanje (34 – 38) i olovaka za izbjeljivanje (29). Horn i suradnici (37) promatrali su učinak izbjeljivanja četiriju pasta za zube poslije 15 dana korištenja i nisu otkrili da i jedna od njih vidljivo mijenja boju zuba. Ni Pintado-Palomino i suradnici (38) nisu pronašli razliku u promjeni boje poslije 4 tjedna korištenja dviju pasta za zube s učinkom izbjeljivanja u usporedbi s konvencionalnom zubnom pastom bez ikakva učinka. Nasuprot tomu, u drugim studijama u literaturi potvrđena je učinkovitost različitih zubnih pasta za izbjeljivanje (39, 40). Bizhang i suradnici (41) procijenili su učinak pripravka gela koji sadržava peroksisaproinsku kiselinu i pokazali znatan učinak poslije samo jedne uporabe. U ovom istraživanju svi ispitanici koji su se koristili olovkom uočili su učinak izbjeljivanja zuba (100%), a 94,7% ispitanika koji su upotrebljavali kombinaciju paste za zube i olovke. Ispitanici su bili zadovoljniji rezultatima postignutima poslije korištenja olovke i kombinacije olovke i zubne paste s učinkom izbjeljivanja, nego samo zubnom pastom za izbjeljivanje ($p \leq 0,001$).

Najčešće neugodne nuspojave pri korištenju proizvoda za izbjeljivanje zuba jesu preosjetljivost dentina i iritacija gingive. Fiorillo i suradnici (42) navode da je izbjeljivanje zuba postupak koji bi trebali izbjegavati pacijenti koji već pate od dentalne preosjetljivosti. Nažalost, djelovanje na tvrda tkiva zuba može pridonijeti pojavi preosjetljivosti. No, ističu i da je estetski učinak izbjeljivanja zuba uvijek prisutan, bilo u kućnim, bilo u profesionalnim tretmanima. Autori vjeruju da poboljšanje estetike osmijeha, u ovom slučaju izbjeljivanjem zuba, poboljšava i kvalitetu života pacijenata. U ovom istraživanju 27,8% ispitanika koji su se koristili olovkom žalilo se na osjetljivost zuba tijekom korištenja, to je učinilo i 21,1% onih koji su upotrebljavali kombinaciju zubne paste s učinkom izbjeljivanja i olovke te 5,2% ispitanika koji su se koristili samo zubnom pastom za izbjeljivanje. Pečenje, iritaciju i osjetljivost u usnoj šupljini osjetilo je manje od 10% ispitanika, bez obzira na korištene materijale. Prijavljena prevalen-

ardless of the materials used. The reported prevalence/incidence of increased tooth hypersensitivity varies between studies, ranging from 0% to 100% [42], although most studies reported a prevalence of 15% to 80% (43). In most cases, tooth hypersensitivity is transient and tends to subside within a few days after completing the whitening treatment (44-46).

The PIDAQ questionnaire was originally developed for use in patients undergoing orthodontic therapy (47). However, the measured dimensions can also be applied to subjects using tooth whitening agents (20,21). Our research showed that the values of the PIDAQ questionnaire for the most of examined dimensions between means for each examined time did not show significant results. The first factor, "dental self-confidence," showed a positive whitening effect for all tested agents between baseline values and those obtained after seven days of use but it was not statistically significant. Dental self-confidence is a positive dimension of the PIDAQ questionnaire that measures the impact of dental aesthetics on an individual's self-confidence. The appearance of the mouth and smile play a significant role in assessing the attractiveness of the face, contributing to improved self-confidence. PIDAQ measures three additional negative values of the psychosocial impact dimension: social impact, psychological impact, and esthetic concern. Social impact assesses potential problems that an individual may face in social situations due to a subjectively unfavorable tooth appearance. Psychological influence assesses feelings of inferiority or dissatisfaction an individual may experience compared to others. Esthetic concern implies the concern or disapproval that arises when an individual faces a mirror or views photographs and/or videos (21). In this research, a significant reduction in the whitening effect on the psychological impact was observed after 14 days of use for all tested products. However, for the whitening pen and the combination of products, a favorable effect was noticed even after just seven days of use ($p \leq 0.001$). This indicates that these specific whitening agents had a quicker and more positive impact on the psychological aspect compared to other tested products, which required longer usage to show similar effects. Bersezio et al. (19) also stated in their study that the total value of the PIDAQ questionnaire did not show significant differences for each time examined. However, their results showed that one week after bleaching, there was a statistically significant difference in all measurement parameters ($p < 0.03$), while after one month, all parameters were statistically significantly higher except social impact ($p < 0.001$). In contrast study, Angel et al. (21), by comparing the efficacy of 6% H_2O_2 gel and 37.5% H_2O_2 gel, found significant changes in the value of the PIDAQ questionnaire after whitening compared to baseline. Dental self-confidence significantly improved after one week, one month, and three months compared to baseline ($p < 0.001$). Social impact, psychological impact, and esthetic concerns were significantly reduced ($p < 0.09$; $p < 0.001$; $p = 0.001$). Also, Fernandez et al. (20), who had compared the effect of 6% and 35% H_2O_2 gel, obtained statistically significant results for all teste the values of the PIDAQ questionnaire for each study time ($p < 0.001$).

In this study, it was undeniably confirmed that the effectiveness of teeth whitening is not necessarily a good indica-

cija/incidencija povećane preosjetljivosti zuba varira između studija u rasponu od 0 do 100 % (42), iako većina njihovih autora izvješćuje o prevalenciji od 15 do 80 % (43). U većini slučajeva preosjetljivost zuba je prolazna i povlači se nekoliko dana poslije završetka tretmana izbjeljivanja (44 – 46).

Upitnik PIDAQ izvorno je nastao za upotrebu kod pacijenata koji su podvrgnuti ortodontskoj terapiji (47). Međutim, izmjerene dimenzije mogu se primijeniti i na ispitanike koji se koriste sredstvima za izbjeljivanje zuba (20, 21). Naše istraživanje pokazalo je da vrijednosti upitnika PIDAQ-a za većinu ispitivanih dimenzija između srednjih vrijednosti za svako ispitivano vrijeme nisu pokazale značajne rezultate. Prvi čimbenik, „dentalno samopouzdanje”, pokazao je pozitivan učinak za sva testirana sredstva za izbjeljivanje zuba između početnih vrijednosti i onih dobivenih poslije 7 dana korištenja, ali nije bio statistički značajan. Dentalno samopouzdanje pozitivna je dimenzija upitnika PIDAQ-a kojim se mjeri utjecaj dentalne estetike na samopouzdanje pojedinca. Izgled usta i osmijeh važni su u procjeni privlačnosti lica i pridonose povećanju samopouzdanja. PIDAQ-om se mjere tri dodatne negativne vrijednosti dimenzije psihosocijalnog utjecaja: društveni utjecaj, psihološki utjecaj i zabrinutost zbog estetike. Društveni utjecaj procjenjuje moguće probleme s kojima se pojedinac može suočiti u društvenim situacijama zbog subjektivno nepovoljnog izgleda zuba. Psihološki utjecaj procjenjuje osjećaje manje vrijednosti ili nezadovoljstva koje pojedinac može doživjeti u usporedbi s drugima. Zabrinutost zbog estetike podrazumijeva zabrinutost ili neodobravanje koje se pojavljuje kada se pojedinac suoči sa zrcalom ili gleda fotografije i/ili videozapise (21). U ovom istraživanju uočeno je znatno smanjenje na psihološki učinak ispitivanih sredstava poslije 14 dana korištenja. No za olovku za izbjeljivanje i kombinaciju proizvoda zabilježen je povoljan učinak već samo poslije 7 dana korištenja ($p \leq 0,001$). To pokazuje da su ta specifična sredstva za izbjeljivanje brže i pozitivnije utjecala na psihološki aspekt u usporedbi s drugim testiranim proizvodima koji su zahtijevali dulju upotrebu da bi postigli slične učinke. Bersezio i suradnici (19) također su u svojoj studiji naveli da ukupna vrijednost upitnika PIDAQ-a nije pokazala značajne razlike za svako ispitano vrijeme. No njihovi rezultati pokazali su da tjedan dana poslije izbjeljivanja postoji statistički značajna razlika u svim mjernim parametrima ($p < 0,03$), a poslije mjesec dana svi su parametri bili statistički znatno viši, osim društvenog utjecaja ($p < 0,001$). Za razliku od studije Angela i suradnika (21), uspoređujući učinkovitost 6 % H_2O_2 gela i 37,5 % H_2O_2 gela, pronašli su znatne promjene u vrijednosti upitnika PIDAQ-a poslije izbjeljivanja u usporedbi s osnovnom vrijednošću. Dentalno samopouzdanje znatno se poboljšalo poslije jednog tjedna, jednog mjeseca i tri mjeseca u usporedbi s početnom vrijednošću ($p < 0,001$). Društveni i psihološki utjecaj te estetski problemi znatno su smanjeni ($p < 0,090$; $p < 0,001$; $p = 0,001$). Također, Fernandez i suradnici (20) koji su uspoređivali učinak 6 % i 35 % H_2O_2 gela, dobili su statistički značajne rezultate za sve testne vrijednosti PIDAQ-a za svako vrijeme istraživanja ($p < 0,001$).

U ovoj studiji doista je potvrđeno da učinkovitost izbjeljivanja zuba nije nužno dobar pokazatelj zadovoljstva pacijena-

tor of patient satisfaction. While teeth whitening products may produce visible changes in tooth color, patient satisfaction with the treatment can be influenced by various factors beyond the whitening effect alone. Sociodemographic characteristics and life style habits can play significant roles in determining how satisfied patients are with the overall outcome of the teeth whitening procedure (9, 48). In this study, a positive association of satisfaction with the whitening treatment was observed in female gender ($\beta=0.373$, $SE=0.174$, $p=0.006$). On the other hand, a negative association with age was observed for both examined variables: total satisfaction ($\beta=-0.089$, $SE=0.012$, $p\leq 0.001$) and color satisfaction ($\beta=0.109$, $SE=0.016$, $p=0.033$). Additionally, there was no correlation found between the change in tooth color and satisfaction with the treatment or the achieved tooth color. Similar to our research, Heinisch et al. (49) also did not find a positive correlation between the whitening effect and patient satisfaction. The degree of satisfaction is difficult to predict due to individual preferences and expectations that may not always align with reality. Patients often express satisfaction with the final treatment result in ways that therapists may not expect (50).

This study has several limitations. First, the study was conducted on a relatively small number of subjects, which may limit the generalizability of the results to a larger population. To improve the strength of the study, future research should consider increasing the sample size to obtain more representative results. Second, the study included only a limited number of commercially available bleaching products. To obtain a more comprehensive picture of the effectiveness of different bleaching agents, further studies should include a wider range of commercially available products. In addition, the study observation period was relatively short, and no long-term follow-up was conducted to assess color stability over time. The original plan was to assess tooth color and subject satisfaction one month after discontinuation of bleach use to investigate color stability. However, the study was discontinued due to the pandemic caused by the Covid 19 virus, thus further highlighting the importance of considering some external factors that may impact research timelines and study outcomes.

Conclusions

With the limitations of this *in vivo* study, it can be concluded that the use of all tested whitening products result in a change in tooth color after 14 days of use. Subjects who used the whitening pen and the combination of whitening toothpaste and pen experienced a significant increase in tooth color compared to those who used toothpaste alone. However, none of the tested products and their combinations had a significant positive impact on participants' satisfaction with the whitening procedure, tooth color, or esthetic perception. It was observed that patients who used the whitening pen reported the greatest number of side effects, thus pointing out the need to adhere to the manufacturer's instructions and limit its use accordingly. In conclusion, over-the-counter products for home use can help maintain the bright col-

or. Dok proizvodi za izbjeljivanje zuba mogu izazvati vidljive promjene u boji zuba, na zadovoljstvo pacijenata tretmanom mogu utjecati razni čimbenici izvan samog učinka izbjeljivanja. Socijalno-demografske karakteristike i navike mogu biti važne u određivanju toga koliko su pacijenti zadovoljni ukupnim ishodom postupka izbjeljivanja (9, 48). U ovoj studiji zabilježena je pozitivna povezanost zadovoljstva tretmanom izbjeljivanja sa ženskim spolom ($\beta = 0,373$, $SE = 0,174$, $p = 0,006$). S druge strane, uočena je negativna povezanost s dobi za obje ispitivane varijable: ukupno zadovoljstvo ($\beta = -0,089$, $SE = 0,012$, $p \leq 0,001$) i zadovoljstvo bojom ($\beta = 0,109$, $SE = 0,016$, $p = 0,033$). Dodatno, nije pronađena korelacija između promjene boje zuba i zadovoljstva tretmanom ili postignutom bojom zuba. Slično kao u našem istraživanju, Heinisch i suradnici (49) također nisu pronašli pozitivnu korelaciju između učinka izbjeljivanja i zadovoljstva pacijenata. Stupanj zadovoljstva teško je predvidjeti zbog individualnih preferencija i očekivanja koja možda nisu uvijek u skladu sa stvarnošću. Pacijenti često izražavaju zadovoljstvo konačnim rezultatom liječenja na načine koje terapeuti možda ne očekuju (50).

Ova studija ima nekoliko ograničenja. Prvo, provedena je na razmjerno malom broju ispitanika, što može ograničiti mogućnost generalizacije rezultata na veću populaciju. Kako bi se poboljšala snaga studije, u budućim bi istraživanjima trebalo razmotriti povećanje veličine uzorka kako bi se dobili reprezentativniji rezultati. Drugo, studija je uključivala samo ograničen broj komercijalno dostupnih proizvoda za izbjeljivanje. Kako bi se dobila sveobuhvatnija slika o učinkovitosti različitih sredstava za izbjeljivanje, u budućim studijama trebalo bi obuhvatiti širi raspon komercijalno dostupnih proizvoda. Uz to i razdoblje promatranja bilo je razmjerno kratko i nije provedeno dugotrajno praćenje za procjenu stabilnosti boje tijekom vremena. Izvorni plan bio je procijeniti boju zuba i zadovoljstvo ispitanika mjesec dana poslije prestanka upotrebe sredstava za izbjeljivanje kako bi se ispitala stabilnost boje. No zbog pandemije koronavirusom studija je prekinuta, što dodatno ističe važnost razmatranja vanjskih čimbenika koji mogu utjecati na vremenske okvire istraživanja i ishode istraživanja.

Zaključak

Uz ograničenja ove studije *in vivo*, može se zaključiti da svi ispitani proizvodi za izbjeljivanje uzrokuju promjenu boje zuba poslije 14 dana korištenja. Ispitanici koji su se koristili olovkom za izbjeljivanje i kombinacijom zubne paste za izbjeljivanje i olovke uspjeli su znatno posvijetliti boju zuba u usporedbi s onima koji su upotrebljavali samo zubnu pastu za izbjeljivanje. No ni jedan od testiranih proizvoda i njihovih kombinacija nije znatno pozitivno utjecao na zadovoljstvo sudionika postupkom izbjeljivanja, bojom zuba ili na estetsku percepciju. Uočeno je da su pacijenti koji su se koristili olovkom za izbjeljivanje prijavili najviše nuspojava, što upozorava na to da je potrebno poštovati upute proizvođača i ograničiti njezinu uporabu u skladu s tim. Zaključno, komercijalni proizvodi za kućnu upotrebu mogu pomoći u održa-

or of teeth, but their impact on satisfaction and esthetics may vary among individuals. Further research and considerations of individual factors are needed to optimize teeth whitening procedures and outcomes.

Ethical approval

The study was conducted according to the guidelines of the Declaration of Helsinki, and approved by the Ethics Committee of School of Medicine, University of Split, Split, Croatia (Class: 003-081 20-03 I0005; No: 2 181-198-03-04-20-0067).

Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

Data Availability Statement

The data that support the findings of this study are available upon request from the authors.

Acknowledgments

The authors would like to express their gratitude to Klaudija Primorac, special territory export manager by Hager & Werken Corporation for generously donating the whitening products used in this study. This study was presented at the 4th International Congress of the Department of Endodontics and Restorative Dentistry, School of Dental Medicine, University of Zagreb in cooperation with the Croatian Society for Minimal Interventional Dental Medicine (23–24 October 2020, Zagreb, Croatia) as an oral presentation, and was written from the results of the diploma thesis: Popovic, S. Evaluation of effectiveness for different tooth whitening agents [undergraduate diploma thesis]. Split: University of Split, School of Medicine; 2020.

Conflicts of Interest

The authors declare no conflict of interest.

Author Contributions: Conceptualization, A.T. and L.G.; Methodology, A.T., S.G. and L.G.; Validation, A.T. and L.G.; Formal Analysis, A.T. and L.G.; Investigation, S.G.; Data Curation, S.G.; Writing – Original Draft Preparation, S.G., A.T., and L.G.; Writing – Review & Editing, S.G., A.T. and L.G.; Supervision, A.T. All authors have read and agreed to the published version of the manuscript.

vanju svjetline boje zuba, ali njihov utjecaj na zadovoljstvo i estetiku među pojedincima može varirati. Potrebna su daljnja istraživanja i razmatranje pojedinačnih čimbenika kako bi se optimizirali postupci i rezultati izbjeljivanja zuba.

Etičko odobrenje

Studija je provedena u skladu sa smjernicama Helsinške deklaracije, a odobrilo ju je Etičko povjerenstvo Medicinskog fakulteta Sveučilišta u Splitu (Klasa: 003-081 20-03 I0005; Br: 2 181 -198-03-04-20-0067).

Izjava o informiranom pristanku

Informirani pristanak dobiven je od svih uključenih u studiju.

Izjava o dostupnosti podataka

Podatci koji podupiru nalaze ove studije dostupni su na zahtjev.

Zahvale

Autori zahvaljuju Klaudiji Primorac, menadžerici prodaje za Adriatic regiju tvrtke Hager i Werken Corporation, na velikodušnoj donaciji proizvoda za izbjeljivanje korištenih u ovoj studiji.

Ova je studija predstavljena na 4. Međunarodnom kongresu Zavoda za endodonciju i restaurativnu stomatologiju Stomatološkog fakulteta Sveučilišta u Zagrebu u suradnji s Hrvatskim društvom za minimalnu intervencijsku dentalnu medicinu (23. – 24. listopada 2020., Zagreb, Hrvatska) kao usmeno izlaganje, a napisana je na temelju rezultata diplomskog rada: Popović, S.: Procjena učinkovitosti različitih sredstava za izbjeljivanje zuba [diplomski preddiplomski rad]. Split: Sveučilište u Splitu, Medicinski fakultet; 2020.

Sukob interesa

Autori nisu bili u sukobu interesa.

Doprinosi autora: A. T. i L.G. – konceptualizacija, validacija, formalna analiza; A. T., S. G. i L. G. – metodologija, pisanje teksta priprema izvornom nacrtu, pregled i uređivanje; S. G. – istraživanje i skupljanje podataka; A. T. – nadzor. Svi su autori pročitali tekst i složili se s objavljenom verzijom.

Sažetak

Svrha: Željela se ispitati učinkovitost komercijalno dostupnih proizvoda za izbjeljivanje zuba te utjecaj tih tretmana na zadovoljstvo ispitanika i njihovu estetsku samopercepciju. **Materijali i metode:** Ukupno 56 sudionika bilo je nasumično raspoređeno u tri skupine prema vrsti proizvoda za izbjeljivanje (zubna pasta, olovka ili kombinacija obaju proizvoda). U ovoj prospektivnoj studiji promjene u boji zuba mjerene su spektrofotometrom u trima različitim vremenskim točkama (početno mjerenje, 7 dana i 14 dana poslije početka korištenja proizvoda za izbjeljivanje). Tijekom tog razdoblja ispitanicima je podijeljen upitnik PIDAQ. Na kraju istraživanja procijenjeno je zadovoljstvo sudionika rezultatima izbjeljivanja (ocjenjivano na Likertovoj ljestvici od pet stupnjeva) i njihova percepcija nuspojava. **Rezultati:** Sudionici koji su se koristili samo olovkom za izbjeljivanje zuba ili u kombinaciji s pastom za izbjeljivanje istaknuli su znatna poboljšanja u boji zuba i indeksu bjeline poslije 7 i 14 dana u usporedbi s onima koji su upotrebljavali samo pastu za izbjeljivanje ($p \leq 0,001$). No nisu pronađene znatne razlike između proizvoda kad je riječ o ukupnom zadovoljstvu tretmanom, percepciji konačne boje zuba i udobnosti tretmana. Osim psihološkog utjecaja, poslije 14 dana ($p \leq 0,001$) nisu uočene značajne razlike u rezultatima upitnika PIDAQ-a između različitih proizvoda za izbjeljivanje zuba u različitim vremenskim točkama. Važno je napomenuti da je 16,6 % ispitanika prijavilo osjetljivost oralne sluznice, a veći postotak, odnosno 27,8 %, istaknuo je osjetljivost zuba tijekom primjene olovke za izbjeljivanje. **Zaključak:** Kombinacija paste za izbjeljivanje zuba i olovke za izbjeljivanje, te samostalna uporaba olovke za izbjeljivanje, pokazala je objektivno učinkovite rezultate u promjeni boje zuba. No primjena komercijalno dostupnih preparata za izbjeljivanje zuba nije znatno utjecala na samopercipirano zadovoljstvo sudionika, ni na njihove psihosocijalne ishode, bez obzira na vrstu korištenog proizvoda.

Zaprimljen: 24. kolovoza 2023.

Prihvaćen: 12. listopada 2023.

Adresa za dopisivanje

Antonija Tadin
Medicinski fakultet, Sveučilište u Splitu
Katedra za restaurativnu dentalnu medicinu i endodonciju,
21 000 Split, Hrvatska
mob: +38598609191
faks: +38521557624
atadin@mefst.hr

MeSH pojmovi: sredstva za izbjeljivanje zubi; izbjeljivanje zubi; boja; zadovoljstvo bolesnika; paste za zube
Autorske ključne riječi: boja zuba, zadovoljstvo pacijenata, nuspojave, izbjeljivanje zuba, pasta za zube, olovka za izbjeljivanje

References

- Demarco FF, Meireles SS, Masotti AS. Over-the-counter whitening agents: a concise review. *Braz Oral Res.* 2009;23 Suppl 1:64-70.
- Yildirim E, Vural UK, Cakir FY, Gurgan S. Effects of Different Over-the-Counter Whitening Products on the Microhardness, Surface Roughness, Color and Shear Bond Strength of Enamel. *Acta Stomatol Croat.* 2022 Jun;56(2):120-131.
- Auschill TM, Hellwig E, Schmidale S, Sculean A, Arweiler NB. Efficacy, side-effects and patients' acceptance of different bleaching techniques (OTC, in-office, at-home). *Oper Dent.* 2005 Mar-Apr;30(2):156-63.
- Vladislavic NZ, Tadin A, Gavic L, Jerkovic D, Franic I, Verzak Z. In vivo evaluation of whitening toothpaste efficiency and patient treatment satisfaction: a randomized controlled trial. *Clin Oral Investig.* 2022 Jan;26(1):739-750.
- Devila A, Lasta R, Zanella L, Agnol MD, Rodrigues-Junior SA. Efficacy and Adverse Effects of Whitening Dentifrices Compared With Other Products: A Systematic Review and Meta-analysis. *Oper Dent.* 2020 Mar/Apr;45(2):E77-E90.
- da Rosa G, Maran BM, Schmitt VL, Loguercio AD, Reis A, Naufel FS. Effectiveness of Whitening Strips Use Compared With Supervised Dental Bleaching: A Systematic Review and Meta-analysis. *Oper Dent.* 2020 Nov 1;45(6):E289-E307.
- Naidu AS, Bennani V, Brunton JMAP, Brunton P. Over-the-Counter Tooth Whitening Agents: A Review of Literature. *Braz Dent J.* 2020 Jun;31(3):221-235.
- Epple M, Meyer F, Enax J. A Critical Review of Modern Concepts for Teeth Whitening. *Dent J (Basel).* 2019 Aug 1;7(3):79.
- Naidu A. Factors affecting patient satisfaction and healthcare quality. *Int J Health Care Qual Assur.* 2009;22(4):366-81.
- Goldberg M, Grootveld M, Lynch E. Undesirable and adverse effects of tooth-whitening products: a review. *Clin Oral Investig.* 2010 Feb;14(1):1-10.
- Bruzell EM, Pallesen U, Thoresen NR, Wallman C, Dahl JE. Side effects of external tooth bleaching: a multi-centre practice-based prospective study. *Br Dent J.* 2013 Nov 8;215(9):E17.
- Carneiro TS, Favoreto MW, Bernardi LG, Sutil E, Wendlinger M, Centenaro GG, Reis A, Loguercio AD. Gingival irritation in patients submitted to at-home bleaching with different cutouts of the bleaching tray: a randomized, single-blind clinical trial. *Clin Oral Investig.* 2022 Jun;26(6):4381-4390.
- Rodríguez-Martínez J, Valiente M, Sánchez-Martín MJ. Tooth whitening: From the established treatments to novel approaches to prevent side effects. *J Esthet Restor Dent.* 2019 Sep;31(5):431-440.
- Pereira R, Silveira J, Dias S, Cardoso A, Mata A, Marques D. Bleaching efficacy and quality of life of different bleaching techniques - randomized controlled trial. *Clin Oral Investig.* 2022 Dec;26(12):7167-7177.
- Estay J, Angel P, Bersezio C, Tonetto M, Jorquera G, Peña M, Fernández E. The change of teeth color, whiteness variations and its psychosocial and self-perception effects when using low vs. high concentration bleaching gels: a one-year follow-up. *BMC Oral Health.* 2020 Sep 11;20(1):255.
- Della Bona A, Pecho OE, Ghinea R, Cardona JC, Paravina RD, Perez MM. Influence of Bleaching and Aging Procedures on Color and Whiteness of Dental Composites. *Oper Dent.* 2019 Nov/Dec;44(6):648-658.
- Paravina RD, Ghinea R, Herrera LJ, Bona AD, Igiel C, Linninger M, Sakai M, Takahashi H, Tashkandi E, Perez Mdel M. Color difference thresholds in dentistry. *J Esthet Restor Dent.* 2015 Mar-Apr;27 Suppl 1:S1-9.
- Joiner A, Luo W. Tooth colour and whiteness: A review. *J Dent.* 2017 Dec;67S:S3-S10.
- Bersezio C, Martín J, Herrera A, Loguercio A, Fernández E. The effects of at-home whitening on patients' oral health, psychology, and aesthetic perception. *BMC Oral Health.* 2018 Dec 11;18(1):208.
- Fernández E, Bersezio C, Bottner J, Avalos F, Godoy I, Inda D, Vildósola P, Saad J, Oliveira OB Jr, Martín J. Longevity, Esthetic Perception, and Psychosocial Impact of Teeth Bleaching by Low (6%) Hydrogen Peroxide Concentration for In-office Treatment: A Randomized Clinical Trial. *Oper Dent.* 2017 Jan/Feb;42(1):41-52.
- Angel P, Bersezio C, Estay J, Werner A, Retamal H, Araya C, Martín J, Fernández E. Color stability, psychosocial impact, and effect on self-perception of esthetics of tooth whitening using low-concentration (6%) hydrogen peroxide. *Quintessence Int.* 2018;49(7):557-566.
- Bonafé E, Rezende M, Machado MM, Lima SNL, Fernandez E, Baldani MMP, Reis A, Loguercio AD, Bandeca MC. Personality traits, psychosocial effects and quality of life of patients submitted to dental bleaching. *BMC Oral Health.* 2021 Jan 6;21(1):7.
- Chang JY, Chen WC, Huang TK, Wang JC, Fu PS, Chen JH, Hung CC. Evaluating the accuracy of tooth color measurement by combining the Munsell color system and dental colorimeter. *Kaohsiung J Med Sci.* 2012 Sep;28(9):490-4.
- Ferreira Dias SB, Lourenço Silveira JM, Nunes Pereira RM, Cardoso AB, Duarte Sola Pereira da Mata A, da Silva Marques DN. CIEL*a*b* values in vita classical and vita 3d master by two dental spectrophotometers. *Int J Prosthodont.* 2021 Mar 18.
- Klaric Sever E, Budimir Z, Cerovac M, Stambuk M, Par M, Negovetic Vranic D, Tarle Z. Clinical and patient reported outcomes of bleaching effectiveness. *Acta Odontol Scand.* 2018 Jan;76(1):30-38.
- Bruno M, Taddeo F, Medeiros IS, Boaro LC, Moreira MS, Marques MM, Calheiros FC. Relationship between toothpastes properties and patient-reported discomfort: crossover study. *Clin Oral Investig.* 2016 Apr;20(3):485-94.
- Fässler M, Meissner K, Schneider A, Linde K. Frequency and circumstances of placebo use in clinical practice--a systematic review of empirical studies. *BMC Med.* 2010 Feb 23;8:15.

28. Greenwall-Cohen J, Francois P, Silikas N, Greenwall L, Le Goff S, Attal JP. The safety and efficacy of 'over the counter' bleaching products in the UK. *Br Dent J*. 2019 Feb;226(4):271-276.
29. Qina J, Zengb L, Mina W, Tanb L, Lvb R, Chenb Y. A bio-safety tooth-whitening composite gels with novel phthalimide peroxy caproic acid. *Compos Commun*. 2019;13107-111.
30. Paravina RD, Pérez MM, Ghinea R. Acceptability and perceptibility thresholds in dentistry: A comprehensive review of clinical and research applications. *J Esthet Restor Dent*. 2019 Mar;31(2):103-112.
31. Kumar S, Duraisamy P, Manipal S, Rajmohan, Bharathwaj, Mungara, M. Comparison of the Whitening Properties of Commercially available Whitening Toothpaste using Shade Vision System: An In Vitro Study. *Int. J Oral Health Med Res*. 2016;3(4):22-26.
32. Vaz VTP, Jubilato DP, Oliveira MRM, Bortolatto JF, Floros MC, Dantas AAR, Oliveira Junior OB. Whitening toothpaste containing activated charcoal, blue covarine, hydrogen peroxide or microbeads: which one is the most effective? *J Appl Oral Sci*. 2019 Jan 14;27:e20180051.
33. Müller-Heupt LK, Wiesmann-Imilowski N, Kaya S, Schumann S, Steiger M, Bjelopavlovic M, Deschner J, Al-Nawas B, Lehmann KM. Effectiveness and Safety of Over-the-Counter Tooth-Whitening Agents Compared to Hydrogen Peroxide In Vitro. *Int J Mol Sci*. 2023 Jan 19;24(3):1956.
34. Torres CR, Perote LC, Gutierrez NC, Pucci CR, Borges AB. Efficacy of mouth rinses and toothpaste on tooth whitening. *Oper Dent*. 2013 Jan-Feb;38(1):57-62.
35. Claydon NC, Moran J, Bosma ML, Shirodaria S, Addy M, Newcombe R. Clinical study to compare the effectiveness of a test whitening toothpaste with a commercial whitening toothpaste at inhibiting dental stain. *J Clin Periodontol*. 2004 Dec;31(12):1088-91.
36. Walsh TF, Rawlinson A, Wildgoose D, Marlow I, Haywood J, Ward JM. Clinical evaluation of the stain removing ability of a whitening dentifrice and stain controlling system. *J Dent*. 2005 May;33(5):413-8.
37. Horn BA, Bittencourt BF, Gomes OM, Farhat PA. Clinical evaluation of the whitening effect of over-the-counter dentifrices on vital teeth. *Braz Dent J*. 2014;25(3):203-6.
38. Pintado-Palomino K, Vasconcelos CV, Silva RJ, Fressatti AL, Motta BJ, Pires-DE-Souza FC, Tirapelli C. Effect of whitening dentifrices: a double-blind randomized controlled trial. *Braz Oral Res*. 2016 Oct 10;30(1):e82.
39. Ghassemi A, Vorwerk L, Cirigliano A, Hooper W, DeSciscio P, Nat-hoo S. Clinical Effectiveness Evaluation of a New Whitening Dentifrice. *J Clin Dent*. 2015;26(3):66-71.
40. Ghassemi A, Vorwerk L, Hooper W, Cirigliano A, DeSciscio P, Nat-hoo S. Extrinsic Stain Removal Effectiveness of a New Whitening Dentifrice. *J Clin Dent*. 2015;26(3):72-5.
41. Bizhang M, Domin J, Danesh G, Zimmer S. Effectiveness of a new non-hydrogen peroxide bleaching agent after single use - a double-blind placebo-controlled short-term study. *J Appl Oral Sci*. 2017 Sep-Oct;25(5):575-584.
42. Fiorillo L, Laino L, De Stefano R, D'Amico C, Bocchieri S, Amoroso G, Isola G, Cervino G. Dental Whitening Gels: Strengths and Weaknesses of an Increasingly Used Method. *Gels*. 2019 Jul 4;5(3):35.
43. Dahl JE, Pallesen U. Tooth bleaching--a critical review of the biological aspects. *Crit Rev Oral Biol Med*. 2003;14(4):292-304.
44. Jorgensen MG, Carroll WB. Incidence of tooth sensitivity after home whitening treatment. *J Am Dent Assoc*. 2002 Aug;133(8):1076-82; quiz 1094-5. doi: 10.14219/jada.archive.2002.0332
45. Piknjač A, Soldo M, Illeš D, Knezović Zlatarić D. Patients' Assessments of Tooth Sensitivity Increase One Day Following Different Whitening Treatments. *Acta Stomatol Croat*. 2021 Sep;55(3):280-290.
46. Klarić E, Par M, Profeta I, Matošević D, Tarle Z. Postoperative Sensitivity after Two in-Office Bleaching Methods. *Acta Stomatol Croat*. 2011;45(2):100-9.
47. Klages U, Claus N, Wehrbein H, Zentner A. Development of a questionnaire for assessment of the psychosocial impact of dental aesthetics in young adults. *Eur J Orthod*. 2006 Apr;28(2):103-11.
48. Matis BA, Cochran MA, Franco M, Al-Ammar W, Eckert GJ, Stropes M. Eight in-office tooth whitening systems evaluated in vivo: a pilot study. *Oper Dent*. 2007 Jul-Aug;32(4):322-7.
49. Heinisch C, Larsson K, Mattsson J, Karlsson S, Alstad T, Bruzell E. Patient Satisfaction and Complications of Over-the-Counter Bleaching Products. *J Oral Hyg Health*. 2015;3:176.
50. Kovacevic Pavicic D, Kolceg M, Lajnert V, Pavlic A, Spalj S. Changes in quality of life induced by tooth whitening are not influenced by global self-esteem: a randomized double-blind placebo-controlled trial. *Odontology*. 2020 Jan;108(1):143-151.