Complementary Therapies in Medicine 47 (2019) 102193

Contents lists available at ScienceDirect

Complementary Therapies in Medicine

journal homepage: www.elsevier.com/locate/ctim

Efficacy of oil pulling therapy with coconut oil on four-day supragingival plaque growth: A randomized crossover clinical trial

Yasemin Sezgin[a,*], Betul Memis Ozgul[b], Nilgun Ozlem Alptekin[a]

[a] Department of Periodontology, Faculty of Dentistry, Baskent University, Bahçelievler, Ankara, Turkey
[b] Department of Pediatric Dentistry Faculty of Dentistry, Baskent University, Bahçelievler, Ankara, Turkey

ARTICLE INFO

Keywords:
Chlorhexidine gluconate
Coconut oil
Dental plaque control
Mouthrinse
Oil pulling therapy

ABSTRACT

Objectives: The aim of this study was to evaluate the plaque-inhibiting effects of oil pulling using 4- day plaque regrowth study model compared to 0.2% chlorhexidine gluconate (CHX) containing mouthrinse.
Design: The study was an observer-masked, randomized, cross-over design clinical trial, involving 29 volunteers to compare 0.2% CHX and oil pulling therapy in a 4- day plaque regrowth model. After the preparatory period, in which the subjects received professional prophylaxis, the subjects commenced rinsing with their allocated rinsed. On day 5 plaque index (PI), gingival index (GI), stain index (SI), bleeding on probing (BOP) were recorded from the subjects. Each participant underwent a 14- day wash out period and then used the other mouthrinse for four days.
Results: Oil pulling therapy presented similar inhibitory activity on plaque regrowth compared with CHX (PI = 1.67 ± 0.24, 1.61 ± 0.20, respectively) with less staining (SI = 0.21 ± 0.13, 0.47 ± 0.27, respectively). In addition, GI and BOP was similar in both groups ($p > 0.05$).
Conclusion: Oil pulling with coconut oil seems to have similar plaque inhibition activity as CHX. In addition it caused less tooth staining than CHX. These findings suggest that oil pulling therapy may be an alternative to CHX rinse.

This study was registered under the Clinical Trials protocol registration system (NCT03962777).

1. Introduction

The primary etiologic factor in the development of periodontal disease is pathogenic microorganisms that colonize on tooth surfaces.[1,2] Thus the daily plaque removal by proper tooth cleaning represents a major factor in preventing periodontal disease.[3] However, it is not easy to implement a proper level of plaque control for many patients because it requires special motivations and manual ability.[4] Studies investigate chemical antimicrobial agents as an alternative to avoid plaque accumulation for situations that cause difficulties, impossibilities for maintaining a proper oral hygiene.[4–6]

Chlorhexidine gluconate (CHX) is considered the most effective chemical plaque inhibitor compared to other tested antiplaque agents based on its properties.[7–9] Its positive properties include broad antibacterial activity, high level substantivity, also it has a strong ability for attachment to saliva, pellicle and oral mucosa and teeth. Its broad antibacterial spectrum of activity varies amongst gram-positive and gram-negative bacteria, yeasts, dermatophytes and some lipophilic viruses. Beside its positive results in inhibiting plaque formation, CHX cause a number of local side effects including taste disturbance, extrinsic tooth and tongue staining, enhanced supragingival calculus, desquamation of oral mucosa.[3,10] These side effects of CHX limit its extensive use and promote interest in research to investigate new agents that have antiplaque activity with minimal side effects.

When investigating new agents old traditions are visited as well. Ayurveda is a 3000–5000 years old tradition of natural whole-body healing system that has its origins in the Vedic culture of India.[11] Recently, it has gained popularity as complementary medicine in other parts of the world as well. It is known that Ayurvedic medicines have been used in the treatment of periodontal diseases for many years.[12,13]

Oil pulling is a method based on Ayurvedic medicine which aims to obtain local and systemic benefits by swirling oils in the oral cavity for a period of 15 min, before spitting it out.[14] Although the exact mechanism of action is not clear, there are some proposed theories. One proposed theory is the saponification or “soap making” process which occurs as a result of alkali hydrolysis of fat.[11] Second theory speculates the inhibition of plaque formation and adhesion of bacteria due to the

* Corresponding author at: Baskent University, Faculty of Dentistry, Department of Periodontology, Ankara, Turkey.
E-mail address: yasemin_tocak@hotmail.com (Y. Sezgin).

https://doi.org/10.1016/j.ctim.2019.102193
Received 24 June 2019; Received in revised form 22 July 2019; Accepted 3 September 2019
Available online 04 September 2019
0965-2299/ © 2019 Elsevier Ltd. All rights reserved.

viscous nature of the oil.[15] According to the third theory, presence of antioxidants in oil prevent lipid peroxidation and thus help to the destruction of microorganisms and potentiating the action of Vitamin E in the oral cavity.[16]

The most commonly used oils for oil pulling are sesame oil and coconut oil. The components of sesame oil (sesamin, sesamolin and sesaminol) has antioxidative properties. Coconut oil is composed of 92% saturated acids, and approximately 50% of which is lauric acid. It has not only anti-inflammatory effect but also substantial antimicrobial activity against a range of microorganisms. These include *Escherichia vulneris, Enterobacater* spp.,*Helicobacter pylori, Staphylococcus aureus, Candida (C)* spp.,*including C. albicans, C. glabrata, C.tropicalis, C. parapsilosis, C. stellatoidea* and *C. krusei* and various viruses.[11,17,18]

The effect of oil pulling on halitosis and the use of oil pulling in addition to conventional oral hygiene practices was investigated in some studies[15,19,20] but to the best knowledge of the authors, no study has evaluated the plaque-inhibiting effects of oil pulling. Therefore this study was conducted to evaluate the plaque-inhibiting effects of oil pulling using 4- day plaque regrowth study model[21,22] compared to 0.2% CHX-containing mouthrinse. The tested hypothesis was that oil pulling would perform plaque regrowth inhibition as well as the CHX-containing mouthrinse.

2. Patients and methods

2.1. Study population

Thirty patients were recruited for this 4-day plaque regrowth study from the 42 screened subjects who referred to Baskent University Faculty of Dentistry, Department of Periodontology from February 2019 to April 2019.[22,23] The research protocol was conducted in full accordance with the Helsinki Declaration of 1975, as revised in 2000 and approved by Institutional Review Board and Ethics Committee of the Baskent University (approval no: 19/04). Written informed consent was obtained from all subjects. This study was registered under the Clinical Trials protocol registration system (NCT03962777). The screening and selection of volunteers were carried out by a single who informed the patients about the study design (NÖA).

2.2. Inclusion and exclusion criteria

After obtaining a detailed medical history and initial clinical examination, patients were included into the study if they had: 1) no systemic disease 2) ≥ 22 natural teeth, 3) no removable or fixed prostheses or fixed and removable orthodontic appliances. The following exclusion criteria were applied: history of antibiotic and anti-inflammatory drug use in previous 6 months, presence of an allergy to any ingredient used in the study, smokers, pregnant or lactating females, history of mouthrinses, gels or chewing gums use that contains antimicrobial agents in the preceding 3 months, having teeth with probing depth ≥4 mm and signs of gingival inflammation, presence of gingival recession ≥2 mm.

2.3. Study design

The study was a single-center, observer masked, cross-over design with subjects randomly allocated to treatment sequences. During a 2-week preparatory period, participants rendered plaque, calculus and stain free by a thorough scaling and polishing of the teeth by both hand and ultrasonic instruments and were instructed in self-performed plaque control. At the end of the preparatory period, all subjects had clinically healthy gingiva.

Participants were randomly allocated to two groups by closed envelop system (BM) and masked to the mouthrinse received. The tested products and regimens of use are shown in Table 1. Mouthrinses were filled in identical but coded bottles. Instructions for usage were written on the bottles. On day 1 (Monday) of each study periods, after disclosing the teeth with erythrosine all subjects received scaling and polishing to remove plaque and extrinsic stain and disclosing of the teeth was repeated. By this way it was confirmed that all participants had a plaque score of 0 at baseline. Subjects were then asked to refrain from all forms of tooth cleaning and to apply the rinsing regimen. The tested agents included the following: 1) 0.2% chlorhexidine mouthrinse (10 mL, twice daily for 30 s) 2) Coconut oil (10 Ml, twice daily 15–20 minute). All agents were to be used after breakfast and dinner and the subjects should be avoided rinsing, eating and drinking during the first hour after rinsing. During the 4- day period, the use of any other rinse, chewing gum or toothpaste was not allowed. The participants were advised to control the rinsing time with a timer and the rinsing method was reminded twice a day during the 4- day period by an investigator who made the allocation (BM). The mouthrinses were in identical bottles and patients were not informed about the products however total subject blindness cannot be possible due to the taste, colour, consistency of the products and also due to rinsing time differences.

Table 1
Clinical parameters of chlorhexidine gluconate (CHX) and oil pulling groups.

Parameter	CHX	Oil pulling	p value
PI	1.61 ± 0.20	1.67 ± 0.24	0.09
SI	0.47 ± 0.27	0.21 ± 0.13	**0.0002**
GI	0.67 ± 0.25	0.60 ± 0.21	0.286
BOP	0.01 ± 0.01	0.09 ± 0.30	0.225

Values are presented as mean ± standard deviation (SD).
PI: plaque index, SI: stain index, GI: gingival index, BOP: bleeding on probing.

On day 5 (Friday), subjects received an oral soft tissue examination, first each subject was scored for staining using Lobene stain index (SI).[24] After that disclosing was performed with erythrosine and plaque scoring was performed using the Turesky et al.[25] modification of the Quigley and Hein index.[26] Stain and plaque indices were recorded from the buccal and lingual surfaces of all fully erupted permanent teeth, with the exception of the third molars. In addition, Gingival Index (GI) and bleeding on probing (BOP) were recorded from six sites of each teeth. All clinical examinations were performed by a single trained and calibrated clinician (YS) who was masked to the study.

After recording the clinical parameters, subjects received a polishing to remove all plaque and tooth stain if present and 14 days of wash out periods were allowed after 4- day period.[27] During the wash out period, the subjects returned to normal oral hygiene methods with a standard toothbrush and a fluoride containing tooth paste. These procedures were repeated until each participant used each of the rinses.

At the end of each interval the subjects were asked to complete a standardized questionnaire to evaluate their attitudes and occurrence of adverse effects with regard to the product used. The patients were asked about the flavor of the mouthrinse, the alteration in the taste of food and drinks, the perception of the plaque reduction, the staining that the mouthrinse created, the feeling to create nausea, the preference of the products. Responses to the questions are based on a five point Likert-type scale which ranged from 1- “very negative” to 5- “very positive” except for the question about the preference of the product. Also at the end of each interval compliance of the subjects were controlled by measuring the remaining mouthrinses in the bottles.

2.4. Sample size estimation

Sample size estimation was performed by using NCSS 2007/PASS program by using 2 × 2 cross-over design non-inferiority test. The primary aim of this study was to compare by the differences in PI scores between the two groups. Sample size calculation suggested that a minimum of 28 patients were needed to demonstrate a 0.13 difference in PI scores between the two groups after treatment (80% power, α of

0.05, standard deviation of 0.86).[5] Considering the dropout rate, to achieve at least 28 patients, a total sample of 30 patients were enrolled in this study.

2.5. Statistical analysis

Data analysis was performed on individual plaque index, gingival index, bleeding on probing scores. Plaque index and stain index were also examined for buccal surfaces of upper arch, buccal surfaces of lower arch, lingual surfaces of upper arch, lingual surfaces of lower arch for anterior and posterior sites.

Data analysis was performed using SPSS for Windows, version 21 (SPSS Inc., Chicago, IL, United States). The data were analyzed for normality of distribution with the Shapiro-Wilk test. Because the data did not result in a normal distribution, Mann-Whitney U test was used to determine the differences between two groups. A p-value less than 0.05 was considered statistically significant in all tests.

3. Results

Of the 42 screened patients, 30 eligible patients recruited and 29 patients completed the study (18 females and 11 males, aged 18–52 years; mean age: 26.3 years). One patient dropped out of the study due to antibiotic use (Fig. 1). Means ± standard deviations for full-mouth plaque index, stain index, gingival index and bleeding on probing scores are shown in Table 1. There were no significant differences between CHX and oil pulling groups in terms of full-mouth plaque index, gingival index and bleeding on probing scores ($p > 0.05$) whereas stain index was statistically higher in CHX group ($p < 0.05$). In CHX group, the mean full mouth stain index was 0.47 ± 0.27 compared to 0.21 ± 0.13 of the oil pulling group.

Table 2 shows the mean plaque and stain index for posterior sites. In these sites the pattern for plaque index was the same as the full mouth plaque index ($p > 0.05$). For the stain index, difference between the two groups was significant in posterior sites except for the lingual surfaces of the upper arch.

Table 3 presents the mean plaque and stain index for anterior sites. In anterior sites, plaque score was 1.57 ± 0.29 and 1.87 ± 0.24 for the CHX group; 1.91 ± 0.28 and 1.99 ± 0.13 in oil pulling group for buccal surfaces of upper and lower arch respectively. These differences between the two groups were statistically significant for buccal surfaces of both upper and lower arch ($p < 0.05$) whereas in the lingual surfaces of upper and lower arch, CHX and oil pulling group did not differ significantly. In terms of stain index, CHX group exhibited higher scores compared to oil pulling group and these differences between the two groups were statistically significant in buccal and lingual surfaces of both the upper and lower arch.

The patients completed the questionnaire after each experimental period and the results are shown in Table 4. With regard to the taste of the product, oil pulling group had higher levels compared to CHX group ($p < 0.05$). Similarly, with regard to the participants alterations in taste perception, oil pulling group had higher levels compared to CHX group ($p < 0.05$). However, participants perception of the plaque reduction, staining that the mouthrinse created and participants evaluation about the nausea experience caused by the mouthrinse did not differ significantly between the groups ($p > 0.05$). In addition, 14 patients (48.3%) reported that if they have to use a mouth rinse they would prefer CHX; whereas 15 patients reported that they would prefer oil pulling. Five of those who preferred CHX reported that although the taste of this product was worse, they preferred it because of the short duration time.

4. Discussion

The current study was designed to compare the antiplaque activity of oil pulling and 0.2% CHX-containing mouthrinse. The results confirmed the hypothesis that oil pulling would perform full-mouth plaque regrowth inhibition as well as the CHX-containing mouthrinse.

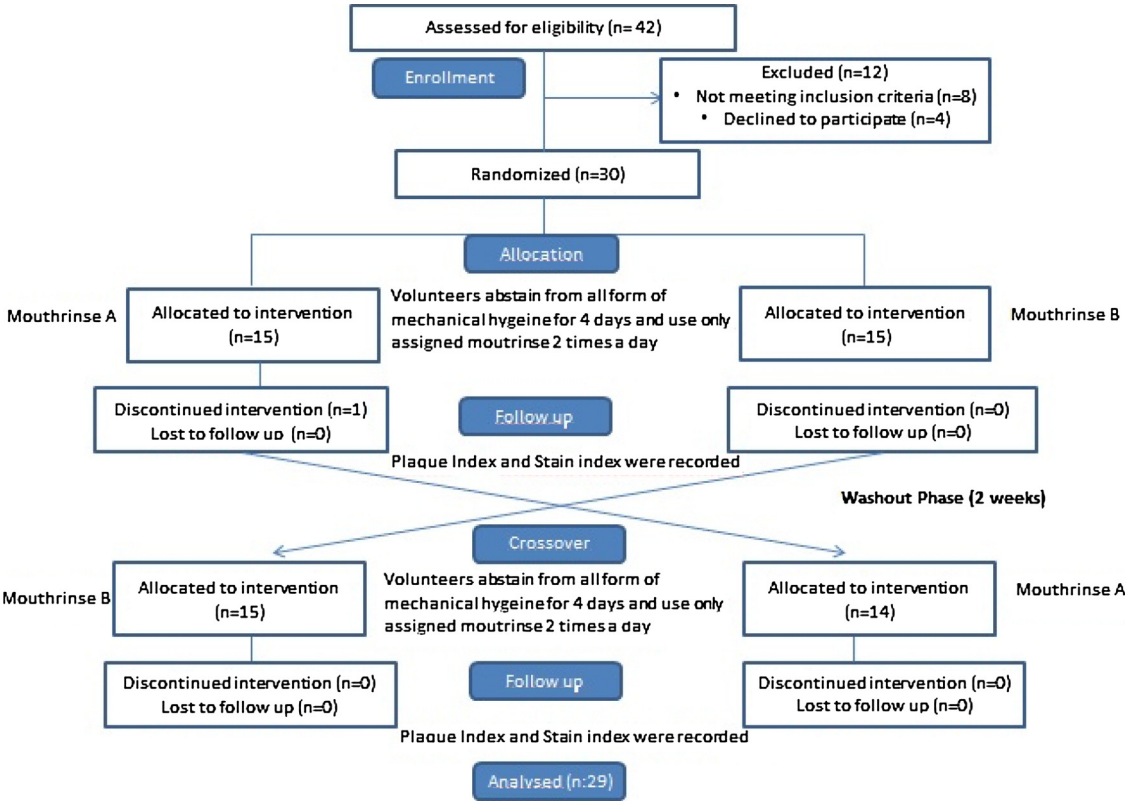

Fig. 1. Flow-chart of the study.

Table 2
Means and standard deviations (SD) of plaque index and stain index of buccal and lingual surfaces of upper and lower arches for posterior sites.

Mouthrinse	Plaque index				Stain index			
	Buccal surfaces		Lingual surfaces		Buccal surfaces		Lingual surfaces	
	Upper arch	Lower arch	Upper arch	Lower arch	Upper arch	Lower arch	Upper arch	Lower arch
CHX	1.64 ± 0.30	1.76 ± 0.29	1.45 ± 0.41	1.69 ± 0.28	0.55 ± 0.39	0.44 ± 0.44	0.57 ± 0.41	0.64 ± 0.45
Oil pulling	1.62 ± 0.25	1.90 ± 0.20	1.53 ± 0.38	1.79 ± 0.19	0.19 ± 0.21	0.18 ± 0.19	0.25 ± 0.25	0.39 ± 0.32
p value	0.672	0.15	0.247	0.15	**0.00021**	**0.002**	1	**0.003**

CHX: *chlorhexidine gluconate.*

Table 3
Means and standard deviations (SD) of plaque index and stain index of buccal and lingual surfaces of upper and lower arches for anterior sites.

Mouthrinse	Plaque index				Stain index			
	Buccal surfaces		Lingual surfaces		Buccal surfaces		Lingual surfaces	
	Upper arch	Lower arch	Upper arch	Lower arch	Upper arch	Lower arch	Upper arch	Lower arch
CHX	1.57 ± 0.29	1.87 ± 0.24	1.39 ± 0.36	1.60 ± 0.37	0.55 ± 0.39	0.44 ± 0.44	0.64 ± 0.47	0.64 ± 0.45
Oil pulling	1.91 ± 0.28	1.99 ± 0.13	1.51 ± 0.41	1.54 ± 0.43	0.19 ± 0.21	0.18 ± 0.19	0.30 ± 0.28	0.39 ± 0.32
P value	**0.0001**	**0.027**	0.226	0.751	**0.00021**	**0.002**	**0.004**	**0.003**

CHX: *chlorhexidine gluconate.*

Table 4
Questionnaire responses.

Questionnaire questions	CHX	Oil pulling	P value
How was the taste of the product?	2.48 ± 0.99	3.17 ± 0.93	**0,005**
How was your taste of food and drinks affected?	2.55 ± 1.12	3.28 ± 0.88	**0.006**
What was your perception of the plaque reduction?	3.48 ± 1.15	3.17 ± 1.04	0.276
How do you evaluate the staining that the mouthrinse created on your teeth?	2.66 ± 1.32	2.97 ± 0.57	0.209
How do you evaluate feeling of nausea created by the mouthrinse that you used?	2.93 ± 0.96	2.83 ± 1.04	0.632

Values are presented as mean ± standard deviation.
CHX: *chlorhexidine gluconate.*

As control of supragingival plaque is critical factor for periodontal disease, the adjunctive use of antimicrobial mouthrinses may be recommended when mechanical oral hygiene is difficult, compromised or impossible. Because its original findings for plaque-inhibitory properties exist widely in the literature, CHX has been usually used as positive control by which other potential plaque-inhibitory agents or formulations are compared. Parallel with the several previous studies that compare an agent's anti-plaque efficacy, CHX has been used as a positive control group in the present study.[5,7,8,12]

In this study 4-day plaque regrowth model was used because it has typical design to assess the efficacy of chemical plaque control methods and to compare the regrowth inhibition efficacy of different agents. This model which avoids tooth brushing for 4 days after professional tooth cleaning is useful to test an agent's efficacy on supragingival plaque regrowth. In addition, this model provides the removal of the confounding factors like the possible interaction between mouthrinse and toothpaste or the Hawthorne effect.[5,28]

The present results showed that oil pulling displayed similar plaque regrowth inhibition with less tooth staining in 4-day plaque regrowth model. Although it is regarded as gold-standard anti-plaque agent, one of the most important disadvantages of CHX that limits its long-term use is the discoloration of the teeth. The other disadvantages of CHX such as unpleasant taste, discoloration of teeth have led to the use of other agents that may be equally effective with minimal disadvantages.[5,12,29] Currently, Ayurvedic drugs are rapidly replacing chemicals for treatment of various diseases, including periodontal diseases because of equivalent potential and lesser side effects.[12] For this purpose it is thought that, oil pulling may be a promising technique alternative to the CHX mouthrinse in the cases which the usage of chemical plaque control agents is indicated for the inhibition of plaque regrowth.

Oil pulling therapy which has both oral and general health benefits involve swishing of oil which has been ancient Ayurvedic practice. It has been used extensively for many years, without scientific evidence as a traditional Indian folk remedy. It is believed that viscosity of oil inhibits bacterial adhesion and plaque aggregation. Also one of the proposed action mechanism of oil pulling is the saponification process that occurs as a result of alkali hydrolysis of fat.[11] Absence of lingering taste, nonstaining of teeth and associated allergies are the advantages of oil pulling therapy over the other chemical agents whereas the extended duration of the procedure may be a disadvantage of the oil pulling therapy compared to chlorhexidine.[20] Beside its proposed advantages, the literature related to oil pulling and dental health is sparse.

The studies focusing on oil pulling did not study the plaque inhibiting effects. In a study that compared the effect of oil pulling with sesame oil on plaque induced gingivitis and compare it with CHX the results showed that statistically significant within-group reductions in PI, GI score and total count of aerobic microorganisms in the plaque for both groups but no significant difference between groups were found.[15] In another study with similar design, it was found that when used adjunctive to daily home oral hygiene procedures, oil pulling therapy showed reduction in *Streptococcus mutans* in the plaque and saliva.[30] Studies which were designed to evaluate the effect of oil pulling on oral malodor showed that oil pulling with sesame oil was effective as chlorhexidine in reducing halitosis and microorganisms associated with halitosis.[20,31]

Present study is the first study that evaluates the plaque-inhibiting effects of oil pulling with coconut oil and compare to 0.2% CHX-

containing mouthrinse using 4- day plaque regrowth study model on the whole group of volunteers after a two-week wash out period and a session of scaling (to obtain a PI of 0). With the crossover design of this study, each patient acts as his/her own control and this allows for greater biological homogeneity.[32]

Oil pulling can be performed by various oils including sunflower oil, sesame oil and coconut oil.[11] Coconut oil is different from most other dietary oils because it is primarily composed of medium chain fatty acid which influences its physical and chemical properties. Coconut oil contains 92% saturated acids, with 50% of which is lauric acid. Lauric acid has proven both anti-inflammatory effect and antimicrobial activity against a range of microorganisms.[17,18] Due to the mentioned features, coconut oil was chosen for oil pulling therapy in the current study.

In addition to full-mouth evaluation, the PI and SI were evaluated at eight different sites (buccal surfaces of upper arch, buccal surfaces of lower arch, lingual surfaces of upper arch, lingual surfaces of lower arch for anterior and posterior sites) to determine if there are some topographical sites that results in different effectiveness of the products. The pattern of efficacy was the same in posterior sites but in the buccal surfaces of anterior sites, plaque inhibition with CHX was significantly greater. Its known that emulsification of oil begins upon 5 min of oil pulling which increases the amount of the oil combined with saliva.[19] Also the extended duration of oil pulling procedure may cause muscle fatigue. These two factors together, may compromise the orientation of the oil in the anterior buccal region of the mouth resulting in lower plaque inhibition activity in anterior buccal sites of both upper and lower jaw.

In the present study, supragingival plaque formation is evaluated only macroscopically using PI and the absence of microbiological evaluation can be regarded as a limitation of the present study. Within limitations, this 4-day plaque regrowth study showed that oil pulling with coconut oil has similar inhibiting effect on plaque regrowth with 0.2% CHX-containing mouthrinse with less disadvantage. Further studies with microbiological analyses are needed to confirm these results.

Similar to present study, several previous studies compared the antiplaque efficacy of a number of formulations with CHX. Aparna et al.[5] compared the antiplaque efficacy of honey mouthrinse with CHX and found that CHX and honey rinses revealed similar plaque regrowth inhibiton. Pradeep et al.[12] evaluated the efficacy of triphala (TRP) mouthwash in reduction of plaque and gingivitis. It was found that reduction in plaque index was similar in TRP and CHX group. Rosin et al.[33] compared polyhexamethylene biguanide, essential oil rinse and a chlorhexidine rinse on bacterial counts and 4-day plaque regrowth and found that both agents showed similar results in inhibiting plaque. Although previous study results are promising in inhibition of plaque regrowth, to date no natural product has been able to completely replace CHX.

The patient preferences and evaluations of the products were also evaluated in the present study. According to the questionnaire, the flavor of the CHX and the change created in the taste sensation was evaluated worse than oil pulling therapy. However patients also felt that the feeling of plaque reduction was similar in both groups. 15 out of 29 patients preferred the use of oil pulling while 14 preferred the use of CHX. Patients explained the reason behind the choice of products, the findings suggest that the short duration use of CHX let to the similar results with coconut oil even though patients did not like to taste. Based on these results oil pulling therapy seems to be a preferable technique to overcome the disadvantages of CHX. However well designed studies should furtherly investigate the effects of oil pulling with coconut oil for inhibition of supragingival plaque formation.

Also in the present study the results were similar, however chlorhexidine gluconate achieved these in shorter period of mouth rinsing due to its chemical content. Choosing the natural over chemical would be beneficial however it should be kept in mind that longer mouth rinsing period is a factor that may lead to a potential disadvantage for patient motivation. Based on this dilemma other potential agents should be studied that may show the same effectiveness as CHX in similar or shorter mouth rinsing periods.

In conclusion even though the results from the present study shows promising results for oil pulling with coconut oil on inhibition of supragingival plaque formation, it also has its limitation for use and would not be able to replace chlorhexidine gluconate yet. Further studies are needed to find a better natural replacement for chemical gold standard chlorhexidine gluconate.

Declaration of Competing Interest

The authors declare that they have no conflicts of interest related to this study.

Acknowledgment

The Baskent University Research Fund, Turkey supported this research (D-KA18/29).

References

1. Loe H, Theilade E, Jensen SB. Experimental gingivitis in man. *J Periodontol.* 1965;36:177–187.
2. Genco RJ, Borgnakke WS. Risk factors for periodontal disease. *Periodontology.* 2000;2013(62):59–94.
3. Santos A. Evidence-based control of plaque and gingivitis. *J Clin Periodontol.* 2003;30(Suppl 5):13–16.
4. Rodrigues IS, de Oliveira DB, de Menezes PC, da Costa FN, Carlos MX, Pereira SL. Effect of Lippia sidoides in mouthrinses on de novo plaque formation: A double-blind clinical study in humans. *Indian J Dent Res.* 2013;24:533–536.
5. Aparna S, Srirangarajan S, Malgi V, et al. A comparative evaluation of the antibacterial efficacy of honey in vitro and antiplaque efficacy in a 4-day plaque regrowth model in vivo: Preliminary results. *J Periodontol.* 2012;83:1116–1121.
6. Graziani F, Gabriele M, D'Aiuto F, Suvan J, Tonelli M, Cei S. Dental plaque, gingival inflammation and tooth -discolouration with different commercial -formulations of 0.2% chlorhexidine rinse: A double-blind randomised controlled clinical trial. *Oral Health Prev Dent.* 2015;13:101–111.
7. Pizzo G, La Cara M, Licata ME, Pizzo I, D'Angelo M. The effects of an essential oil and an amine fluoride/stannous fluoride mouthrinse on supragingival plaque regrowth. *J Periodontol.* 2008;79:1177–1183.
8. Jones CG. Chlorhexidine: Is it still the gold standard? *Periodontology.* 2000;1997(15):55–62.
9. Supranoto SC, Slot DE, Addy M, Van der Weijden GA. The effect of chlorhexidine dentifrice or gel versus chlorhexidine mouthwash on plaque, gingivitis, bleeding and tooth discoloration: A systematic review. *Int J Dent Hyg.* 2015;13:83–92.
10. McCoy LC, Wehler CJ, Rich SE, Garcia RI, Miller DR, Jones JA. Adverse events associated with chlorhexidine use: Results from the Department of Veterans Affairs Dental Diabetes Study. *J Am Dent Assoc.* 2008;139:178–183.
11. Naseem M, Khiyani MF, Nauman H, Zafar MS, Shah AH, Khalil HS. Oil pulling and importance of traditional medicine in oral health maintenance. *Int J Health Sci.* 2017;11:65–70.
12. Pradeep AR, Suke DK, Martande SS, Singh SP, Nagpal K, Naik SB. Triphala, a new herbal mouthwash for the treatment of gingivitis: A randomized controlled clinical trial. *J Periodontol.* 2016;87:1352–1359.
13. Abraham S, Kumar MS, Sehgal PK, Nitish S, Jayakumar ND. Evaluation of the inhibitory effect of triphala on PMN-type matrix metalloproteinase (MMP-9). *J Periodontol.* 2005;76:497–502.
14. Gbinigie O, Onakpoya I, Spencer E, McCall MacBain M, Heneghan C. Effect of oil pulling in promoting oro dental hygiene: A systematic review of randomized clinical trials. *Complement Ther Med.* 2016;26:47–54.
15. Asokan S, Emmadi P, Chamundeswari R. Effect of oil pulling on plaque induced gingivitis: A randomized, controlled, triple-blind study. *Indian J Dent Res.* 2009;20:47–51.
16. Asokan S, Rathinasamy TK, Inbamani N, et al. Mechanism of oil-pulling therapy - in vitro study. *Indian Society for Dental Research.* 2011;22:34–37.
17. Carpo BG, Verallo-Rowell VM, Kabara J. Novel antibacterial activity of monolaurin compared with conventional antibiotics against organisms from skin infections: An in vitro study. *J Drugs Dermatol.* 2007;6:991–998.
18. Verallo-Rowell VM, Dillague KM, Syah-Tjundawan BS. Novel antibacterial and emollient effects of coconut and virgin olive oils in adult atopic dermatitis. *Dermatitis.* 2008;19:308–315.
19. Shanbhag VK. Oil pulling for maintaining oral hygiene - A review. *J Tradit Complement Med.* 2017;7:106–109.
20. Asokan S, Kumar RS, Emmadi P, Raghuraman R, Sivakumar N. Effect of oil pulling on halitosis and microorganisms causing halitosis: A randomized controlled pilot trial. *J Indian Soc Pedod Prev Dent.* 2011;29:90–94.
21. Addy M, Moran JM. Evaluation of oral hygiene products: Science is true; don't be misled by the facts. *Periodontology.* 2000;1997(15):40–51.

22. Addy M, Willis L, Moran J. Effect of toothpaste rinses compared with chlorhexidine on plaque formation during a 4-day period. *J Clin Periodontol.* 1983;10:89–99.
23. Ramberg P, Furuichi Y, Lindhe J, Gaffar A. A model for studying the effects of mouthrinses on de novo plaque formation. *J Clin Periodontol.* 1992;19:509–520.
24. Lobene RR. Effect of dentifrices on tooth stains with controlled brushing. *J Am Dent Assoc.* 1968;77:849–855.
25. Turesky S, Gilmore ND, Glickman I. Reduced plaque formation by the chloromethyl analogue of victamine C. *J Periodontol.* 1970;41:41–43.
26. Quigley GA, Hein JW. Comparative cleansing efficiency of manual and power brushing. *J Am Dent Assoc.* 1962;65:26–29.
27. Newcombe RG, Addy M, McKeown S. Residual effect of chlorhexidine gluconate in 4-day plaque regrowth crossover trials, and its implications for study design. *J Periodont Res.* 1995;1995(30):319–324.
28. Barkvoll P, Rolla G, Svendsen K. Interaction between chlorhexidine digluconate and sodium lauryl sulfate in vivo. *J Clin Periodontol.* 1989;16:593–595.
29. Brecx M, Macdonald LL, Legary K, Cheang M, Forgay MG. Long-term effects of Meridol and chlorhexidine mouthrinses on plaque, gingivitis, staining, and bacterial vitality. *J Dent Res.* 1993;72:1194–1197.
30. Asokan S, Rathan J, Muthu MS, Rathna PV, Emmadi P. Raghuraman, Chamundeswari. Effect of oil pulling on Streptococcus mutans count in plaque and saliva using Dentocult SM Strip mutans test: A randomized, controlled, triple-blind study. *J Indian Soc Pedod Prev Dent.* 2008;26:12–17.
31. Sood P, Devi MA, Narang R, V S, Makkar DK. Comparative efficacy of oil pulling and chlorhexidine on oral malodor: A randomized controlled trial. *J Clin Diagn Res.* 2014;8:18–21.
32. Mills EJ, Chan AW, Wu P, Vail A, Guyatt GH, Altman DG. Design, analysis, and presentation of crossover trials. *Trials.* 2009;10:27.
33. Rosin M, Welk A, Kocher T, Majic-Todt A, Kramer A, Pitten FA. The effect of a polyhexamethylene biguanide mouthrinse compared to an essential oil rinse and a chlorhexidine rinse on bacterial counts and 4-day plaque regrowth. *J Clin Periodontol.* 2002;29:392–399.