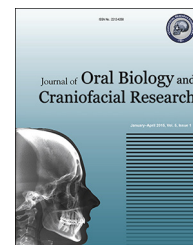


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Original Article

Effect of Aloe vera, chlorine dioxide, and chlorhexidine mouth rinses on plaque and gingivitis: A randomized controlled trial



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ABSTRACT

Objective: To evaluate the effect of Aloe vera, chlorine dioxide, and chlorhexidine mouth rinses on plaque and gingivitis in orthodontic treatment.

Materials and methods: A randomized single-center, single-blind, parallel group, controlled trial was conducted among 90 subjects undergoing fixed orthodontic treatment. The subjects were randomly divided into one of the three study groups (Aloe vera, chlorhexidine, chlorine dioxide). Plaque and gingivitis were assessed using modified Silness and Loe Plaque Index and Gingival Index at baseline and at follow-up after 15 days. Paired t-test and ANOVA with post hoc Dunnett test were used. A *p*-value of <0.05 was considered statistically significant.

Results: A total of 85 participants completed the study; among them, 40 were male and 45 were female. There was significant reduction in mean plaque and gingival scores in all the 3 groups at follow-up when compared to baseline. A significantly higher reduction (plaque and gingival scores) was found in chlorhexidine when compared with the Aloe vera group. However, no significant difference was seen between chlorhexidine and chlorine dioxide with respect to mean reduction in plaque and gingival scores.

Conclusion: Chlorine dioxide can be a suitable and economical alternative for chlorhexidine. Further long-term studies are recommended for evaluating their effectiveness.

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1. Introduction

Periodontal diseases (gingivitis and periodontitis) and dental caries are the two most prevalent oral diseases for which

plaque is the common etiological factor.¹ Plaque control is the basis and goal for prevention of gingivitis, periodontitis, and dental caries and mechanical plaque control is the most dependable way of achieving oral health benefits. However, complete plaque removal is difficult to achieve and prevention

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can be achieved by reducing the quantity of plaque below the threshold level for disease or by changing the quality of plaque toward more protective composition.²

It is known that adequate plaque control is difficult in patients undergoing orthodontic treatment, especially in the cases of children and adolescents. According to Lundstrom and Hampton,³ it is particularly difficult to maintain an acceptable oral hygiene when bands, wires, and ligatures are involved. Fixed orthodontic appliances in oral cavity lead to favorable conditions for the development of dental plaque and eventually increasing the bacterial load. Zachrisson and Zachrisson reported the development of hyperplastic gingivitis within 1-2 months after placement of appliances.⁴ A thorough home care plaque control program (both mechanical and chemical) would reverse the inflammatory changes in the gingival tissues.⁵

A wide array of products for mechanical (tooth brushing and flossing) and chemical plaque control measures is commercially available. Antimicrobial mouth rinses are one such product that is recommended to be an adjunct to mechanical plaque control.⁶⁻⁸ The clinical effectiveness of the mouthrinses that contain active agents, such as chlorhexidine, triclosan, and cetylpyridinium chloride have been well documented.⁹⁻¹¹ Adverse effects like disturbance in taste sensation, tooth staining, and desquamation or soreness of oral mucosa over long-term usage were also well documented.^{12,13} Triclosan has been suspected to cause resistant strains of bacteria and allergic contact dermatitis¹⁴ while cetylpyridinium chloride mouthrinse has been found to cause tooth staining and burning sensation.¹⁵ Hence, there is an increasing demand to explore for alternative agents, which have minimal or no adverse effects over extended usage.¹⁶ Among many other agents developed, Aloe vera and chlorine dioxide showed promising results.

Aloe vera is a medicinal plant with mucilaginous tissue in the center of the leaf. It has been traditionally used for treatment of digestive tract disorders, sunburn, and wounds. The active compounds include aloesin, aloin, aloeride, naftoquinones, methylchromones, flavonoids, saponin, sterols, etc. Various in vitro and in vivo studies reported the pharmacological actions of Aloe vera gel, viz., anti-inflammatory, antibacterial, antiulcer, and antioxidant.¹⁷⁻²⁰ Considering the beneficial effects along with ease of availability, low cost, and no known adverse effects, Aloe vera could be a suitable alternative for prolonged use as plaque control agent.

Recently, a mouth rinse containing chlorine dioxide (ClO₂) has become commercially available in the market (Freshclor, Group Pharmaceuticals Ltd, Bangalore, India). Its active ingredient is sodium chlorite as stabilized chlorine dioxide. Oral rinses containing ClO₂ are now utilized in dental practices as a topical antiseptic for oral cavity and dentures.^{21,22} Previous studies have suggested that ClO₂ and chlorite anion are powerful bactericidal agents to most of the periodontogenic microorganisms.²³⁻²⁵ It was also shown to be effective in treating halitosis, plaque, and gingivitis.^{26,27}

Owing to minimal adverse effects of these newer materials when compared to clinical gold standard (chlorhexidine), it is worthwhile to evaluate the effectiveness of these agents among patients undergoing fixed orthodontic treatment. Hence, we aimed to conduct a randomized controlled trial

to evaluate the effect of Aloe vera, chlorine dioxide, and chlorhexidine mouth rinses on plaque and gingivitis in orthodontic patients.

2. Materials and methods

A randomized single-center, single-blind, parallel group, controlled trial was conducted among subjects undergoing orthodontic treatment. The study was registered with Clinical Trial Registry of India (CTRI/2014/08/004844). Ethical approval to conduct the study was obtained from the Ethics Committee, Kasturba Medical College, Manipal. Subjects aged more than 18 years of age, with visible plaque and gingivitis in at least 30% of the teeth examined and those who were undergoing fixed orthodontic treatment for more than 3 months, were recruited from Department of Orthodontics, Manipal College of Dental Sciences, Manipal University, Manipal. Subjects with multiple restorations and gross dental caries, any form of topical or systemic antibiotic treatment during the past 2 weeks, current users of tobacco in any form, current users of any other mouth rinse, antimicrobials, or any medications, and subjects with functional or removable appliances were excluded.

All the participants were screened for inclusion and exclusion criteria, and 90 eligible participants were included. Participants were explained about the study and informed consent was obtained. Clinical examination to assess plaque accumulation and gingivitis was done by a single trained and calibrated examiner (YSK). Plaque and gingivitis were assessed using modified Silness and Loe Plaque Index (William et al., 1991) and Gingival Index (Loe and Silness, 1963) at baseline and at follow-up after 15 days (Fig. 1).

Allocation concealment was done by the investigator (PKC) who was not involved in clinical examination and was revealed after the completion of the study. Eligible subjects were called for picking one number from the bowl which was numbered as per the allocation concealment. This procedure ensured that the subjects were randomly divided into one of the three study groups (Aloe vera, chlorhexidine, chlorine

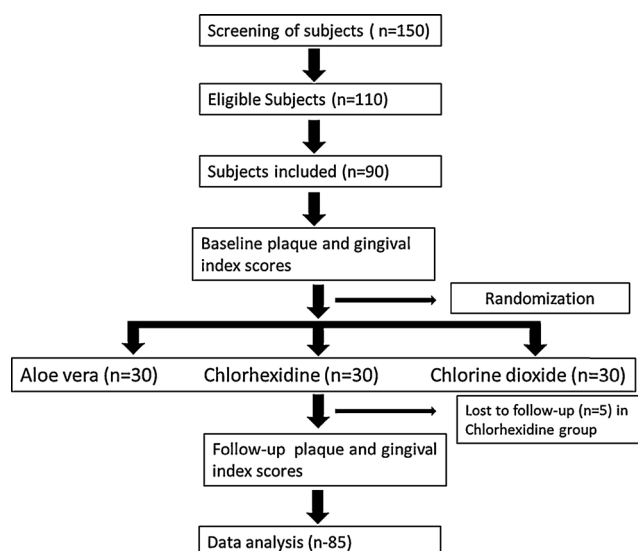


Fig. 1 – Experimental flow diagram of study.

dioxide). After thorough examination for plaque and gingivitis, all the subjects received oral hygiene instructions along with 300 ml of mouth rinse. Subjects were instructed to rinse with 10 ml of mouth rinse for 1 min, twice daily for 15 days.

2.1. Statistical analysis

All the data were analyzed using SPSS version 16.0. Paired t-test was used for intragroup comparison between baseline and follow-up. ANOVA with post hoc Dunnett test was used for intergroup comparison of mean percentage reduction of plaque and gingival scores. A *p*-value of <0.05 was considered statistically significant.

3. Results

A total of 90 participants who were under fixed orthodontic treatment were included in the study (*n* = 30 in each group). Five participants were lost to follow-up due to noncompliance (*n* = 5) in chlorhexidine group. A total of 85 participants completed the study, among them, 40 were male and 45 were female. The mean age and SD of the participants in Aloe vera, chlorhexidine, and chlorine dioxide groups was 21.53 (\pm 3.41), 21.72 (\pm 4.67), and 21.70 (\pm 3.01) years, respectively (Table 1).

The plaque scores in Aloe vera group reduced from 1.27 (\pm 0.38) to 0.98 (\pm 0.30), in chlorhexidine group it reduced from 1.27 (\pm 0.37) to 0.86 (\pm 0.30), and in chlorine dioxide group it reduced from 1.30 (\pm 0.60) to 0.84 (\pm 0.27). Similarly, the gingival

scores in Aloe vera group reduced from 1.53 (\pm 0.37) to 1.36 (\pm 0.27), in chlorhexidine group it reduced from 1.63 (\pm 0.36) to 1.35 (\pm 0.30), and in chlorine dioxide group it reduced from 1.43 (\pm 0.36) to 1.23 (\pm 0.19). There was significant reduction in mean plaque and gingival scores in all the 3 groups at follow-up when compared to baseline (Table 2).

The mean percentage reduction of plaque index scores in Aloe vera, chlorhexidine, and chlorine dioxide groups was 20.38 (\pm 16.74), 31.59 (\pm 16.58), and 30.29 (\pm 18.30), respectively. The mean percentage reduction of Gingival index scores in Aloe vera, chlorhexidine, and chlorine dioxide groups was 9.88 (\pm 8.77), 16.30 (\pm 9.98), and 12.22 (\pm 9.30), respectively. A significantly higher reduction was found in chlorhexidine when compared with Aloe vera groups with respect to plaque and gingival scores. However, no significant difference was seen between chlorhexidine and chlorine dioxide with respect to mean reduction in plaque and gingival scores (Table 3).

4. Discussion

Our study was done to evaluate the efficacy of Aloe vera, chlorhexidine, and chlorine dioxide mouth rinses against plaque and gingivitis over a period of 15 days in patients undergoing fixed orthodontic treatment. Many studies in the literature compared the efficiency of Aloe vera or chlorine dioxide mouth rinses with chlorhexidine and/or placebo rinses (saline or distilled water).

Table 1 – Distribution of participant's according to age and gender.

| | | Aloe vera | Chlorhexidine | Chlorine dioxide |
|--------------|---------------|------------------|------------------|------------------|
| Gender N (%) | Male | 12 (40) | 14 (56) | 14 (46.7) |
| | Female | 18 (60.0) | 11 (44) | 16 (53.3) |
| Age | Mean \pm SD | 21.53 \pm 3.41 | 21.72 \pm 4.67 | 21.70 \pm 3.01 |

Table 2 – Comparison of mean plaque and gingival scores between baseline and follow up in Aloe vera, chlorhexidine and chlorine dioxide groups.

| Group | Index scores | Baseline Mean \pm SD | Follow-up Mean \pm SD | <i>p</i> -value |
|------------------|--------------|---------------------------|----------------------------|-----------------|
| Aloe vera | Plaque | 1.27 \pm 0.38 | 0.98 \pm 0.30 | <0.001 |
| | Gingival | 1.53 \pm 0.37 | 1.36 \pm 0.27 | <0.001 |
| Chlorhexidine | Plaque | 1.27 \pm 0.37 | 0.86 \pm 0.30 | <0.001 |
| | Gingival | 1.63 \pm 0.36 | 1.35 \pm 0.30 | <0.001 |
| Chlorine dioxide | Plaque | 1.30 \pm 0.60 | 0.84 \pm 0.27 | <0.001 |
| | Gingival | 1.43 \pm 0.36 | 1.23 \pm 0.19 | <0.001 |

Table 3 – Comparison of mean percentage reduction of plaque and gingival scores between Aloe vera, chlorhexidine, and chlorine dioxide groups.

| Percentage reduction | Aloe vera | Chlorhexidine | Chlorine dioxide | <i>p</i> -value | Post hoc test |
|----------------------|-------------------|-------------------|-------------------|-----------------|---------------|
| Plaque score | 20.38 \pm 16.74 | 31.59 \pm 16.58 | 30.29 \pm 18.30 | 0.03* | CH > AV |
| Gingival score | 9.88 \pm 8.77 | 16.30 \pm 9.98 | 12.22 \pm 9.03 | 0.04* | CH > AV |

ANOVA with post hoc Dunnett test.

* *p* < 0.05.

The plaque and gingival scores significantly decreased in all the 3 groups at follow-up when compared to baseline, which was in accordance with previous studies.^{2,28} The reduction in plaque scores in Aloe vera group could be attributed due to the active compounds like aloesin, aloin, aloeride, flavonoids, saponin, and sterols.^{29,30} These compounds also have shown antibacterial, anti-inflammatory, and antioxidant properties causing reduction in both plaque and gingival scores.¹⁷⁻²⁰ Similarly, chlorine dioxide also reported to have antibacterial properties by disrupting protein synthesis, inactivating enzymes, and misbalancing electrolytes within cell membranes.^{26,31,23} In addition, it oxidizes VSCs, which are also responsible for local inflammation and the progression of periodontal disease.³² The antimicrobial action of chlorhexidine was established previously in numerous studies.³³⁻³⁵ Mechanism of action is mainly by binding to microbial cell membranes and damaging the surface structure, leading to an osmotic imbalance and precipitation of cytoplasm causing cell death.³⁶

All the 3 groups have the ability to reduce the plaque and gingival scores but the reduction in scores varied. The highest percentage reduction of plaque scores was found in chlorhexidine group (31.59%) followed by chlorine dioxide group (30.29%) and Aloe vera group (20.38%). Similarly, the percentage reduction of gingival scores was maximum in chlorhexidine group (16.30%) followed by chlorine dioxide group (12.22%) and Aloe vera group (9.88%) showed the least reduction. Chlorhexidine showed significantly higher reduction of both plaque and gingival scores when compared to Aloe vera, while no significant difference was found between chlorhexidine and chlorine dioxide or chlorine dioxide and Aloe vera groups.

Although mechanical plaque control can be an effective strategy for preventing the progression of periodontal diseases, most individuals do not adequately brush their teeth, and use a dental floss on a daily basis. The daily use of an effective mouth rinse is generally considered a simple strategy and most patients can easily incorporate this into their home care routine.

Ainamo (1977)³⁷ suggested that the use of chlorhexidine can be a motivational factor for patients. It would make the patients aware of the sensation of cleanliness so they could make applications and develop their mechanical abilities for controlling plaque. Various chemical mouthwashes are available in market but are associated with side effects like immediate hypersensitivity reactions, toxicity, tooth staining, etc. Alternative medicines developed from medicinal plants can replace synthetic drugs and their potential side effects. Aloe vera mouthwash is also cost-effective when compared to chlorhexidine gluconate mouthwash. Chlorine dioxide is another such alternative that is used widely in various fields for its safe and high antibacterial action.^{27,24} Sodium chlorite (NaClO₂), equivalent to ClO₂, the traditional ingredient in almost all oxygen supplementations today, is a nontoxic substance approved by the U.S. Food and Drug Administration as an antimicrobial agent.

Plaque accumulation, gingivitis, and poor oral hygiene are highly prevalent in subjects undergoing orthodontic treatment due to presence of brackets and arch wires that hinder the normal removal of plaque and food debris. Hence, the need for mouth rinse supplement for long periods is highly felt among

the dentists. In the present study, Aloe vera and chlorine dioxide showed almost similar reductions in plaque and gingivitis when compared to chlorhexidine over a period of 15 days. Hence, from the results of the study it can be concluded that chlorine dioxide and Aloe vera can be a suitable and economical alternative for chlorhexidine. Further long-term studies are recommended for evaluating their effectiveness.

Conflicts of interest

The authors have none to declare.

REFERENCES

1. Wu CD, Savitt ED. Evaluation of the safety and efficacy of over-the-counter oral hygiene products for the reduction and control of plaque and gingivitis. *Periodontology*. 2002;2000(28):91-105.
2. Chandrasah B, Jayakumar A. A randomized, double-blind clinical study to assess the antiplaque and antigingivitis efficacy if Aloe vera mouth rinse. *J Indian Soc Periodontol*. 2012;16:543-548.
3. Lundstrom F, Hampton SE. Effect of oral hygiene education on children with and without subsequent orthodontic treatment. *Scand J Dent Res*. 1980;88:53-59.
4. Zachrisson S, Zachrisson BU. Gingival condition associated with orthodontic treatment. *Angle Orthod*. 1972;42:26-34.
5. Kloehn JS, Pfeiffer JS. The effect of orthodontic treatment on the periodontium. *Angle Orthod*. 1974;44:127-134.
6. Anderson GB, Bowden J, Morrison EC, Caffesse RG. Clinical effects of chlorhexidine mouthwashes on patients undergoing orthodontic treatment. *Am J Orthod Dentofacial Orthop*. 1997;111:606-612.
7. Tufekci E, Casagrande ZA, Lindauer SJ, Fowler CE, Williams KT. Effectiveness of an essential oil mouthrinse in improving oral health in orthodontic patients. *Angle Orthod*. 2008;78:294-298.
8. Maruo I, Rosa E, Maruo H, et al. Effect of chlorhexidine mouth rinse on Streptococci counts of tooth-tissue-borne palatal expander biofilm. *Orthod Craniofac Res*. 2008;11:136-142.
9. Haps S, Slot D, Berchier C, Van der Weijden G. The effect of cetylpyridinium chloride-containing mouth rinses as adjuncts to toothbrushing on plaque and parameters of gingival inflammation: a systematic review. *Int J Den Hyg*. 2008;6:290-303.
10. Quirynen M, Avontroodt P, Peeters W, Pauwels M, Coucke W, Van Steenberghe D. Effect of different chlorhexidine formulations in mouthrinses on de novo plaque formation. *J Clin Periodontol*. 2001;28:1127-1136.
11. Moran J, Addy M, Newcombe R, Marlow I. A study to assess the plaque inhibitory activity of a new triclosan mouthrinse formulation. *J Clin Periodontol*. 2000;27:806-809.
12. Fardal O, Turnbull R. A review of the literature on use of chlorhexidine in dentistry. *J Am Dent Assoc*. 1986;112:863-869.
13. Jones CG. Chlorhexidine: is still the gold standard? *Periodontology*. 1997;2000(15):55-62.
14. Bhutani T, Jacob SE. Triclosan: a potential allergen in suture-line allergic contact dermatitis. *Dermatol Surg*. 2009;35:888-889.
15. Rawlinson A, Pollington S, Walsh TF, et al. Efficacy of two alcohol-free cetylpyridinium chloride mouthwashes – a randomized double-blind crossover study. *J Clin Periodontol*. 2008;35:230-235.

16. Haffajee AD, Yaskell T, Socransky SS. Antimicrobial effectiveness of an herbal mouthrinse compared with an essential oil and a chlorhexidine mouthrinse. *J Am Dent Assoc.* 2008;139:606-611.
17. Reynolds T, Dweck AC. Aloe vera leaf gel: a review update. *J Ethnopharmacol.* 1999;68:3-37.
18. Vogler BK, Ernst E. Aloe vera: a systemic review of its clinical effectiveness. *Br J Gen Pract.* 1999;49:823-828.
19. Ndhkala AR, Amoo SO, Stafford GI, Finnie JF, Van Staden J. Antimicrobial, anti-inflammatory and mutagenic investigation of the South African tree Aloe (*Aloe barberae*). *J Ethnopharmacol.* 2009;124:404-408.
20. Pandey R, Mishra A. Antibacterial activities of crude extract of *Aloe barbadensis* to clinically isolated bacterial pathogens. *Appl Biochem Biotechnol.* 2010;160:1356-1361.
21. Gornitsky M, Paradis I, Randaverde G, Malo AM, Velly AM. A clinical and microbiological evaluation of denture cleansers for geriatric patients in long-term care institutions. *J Can Dent Assoc.* 2002;68:39-45.
22. Mohammad AR, Giannini PJ, Preshaw PM, Alliger H. Clinical and microbiological efficacy of chlorine dioxide in the management of chronic atrophic Candidiasis: an open study. *Int Dent J.* 2004;54:154-158.
23. Yates R, Moran J, Addy M, Mullan PJ, Wade WG, Newcombe R. The comparative effect of acidified sodium chlorite and chlorhexidine mouthrinses on plaque regrowth and salivary bacterial counts. *J Clin Periodontol.* 1997;24:603-609.
24. Grootveld M, Silwood C, Gill D, Lynch E. Evidence for the microbicidal activity of a chlorine dioxide-containing oral rinse formulation in vivo. *J Clin Dent.* 2001;12:67-70.
25. Lynch E, Sheerin A, Claxson AWD, et al. Multicomponent spectroscopic investigations of salivary antioxidant consumption by an oral rinse preparation containing the stable free radical species chlorine dioxide (ClO₂). *Free Radic Res.* 1997;26:209-234.
26. Shinada K, Ueno M, Konishi C, et al. Effects of a mouthwash with chlorine dioxide on oral malodor and salivary bacteria: a randomized placebo-controlled 7-day trial. *Trials.* 2010;11:14.
27. Silwood CJL, Grootveld MC, Lynch E. A multifactorial investigation of the ability of oral health care products (OHCPs) to alleviate oral malodour. *J Clin Periodontol.* 2001;28:634-641.
28. Karim B, Bhaskar DJ, Agali C, et al. Effect of Aloe vera mouthwash on periodontal health: triple blind randomized control trial. *Oral Health Dent Manag.* 2014;13:14-19.
29. Kaithwas G, Kumar A, Pandey H, et al. Investigation of comparative antimicrobial activity of Aloe vera gel and juice. *Pharmacology.* 2008;1:1239-1243.
30. Fani M, Kohanteb J. Inhibitory activity of Aloe vera gel on some clinically isolated cariogenic and periodontopathic bacteria. *J Oral Sci.* 2012;54:15-21.
31. Al-bayaty F, Taiyeb-ali T, Abdulla MA, Hashim F. Antibacterial effect of chlorine dioxide and hyaluronate on dental biofilm. *Afr J Microbiol Res.* 2010;4:1525-1531.
32. Yaegaki K, Sanada K. Biochemical and clinical factors influencing oral malodor in periodontal patients. *J Periodontol.* 1992;63:783.
33. Van Strydonck DA, Slot DE, Van der Velden U, Van der Weijden F. Effect of a chlorhexidine mouthrinse on plaque, gingival inflammation and staining in gingivitis patients: a systematic review. *J Clin Periodontol.* 2012;39:1042-1055.
34. de Souza-Filho FJ, Soares Ade J, Vianna ME, Zaia AA, Ferraz CC, Gomes BP. Antimicrobial effect and pH of chlorhexidine gel and calcium hydroxide alone and associated with other materials. *Braz Dent J.* 2008;19:28-33.
35. Gomes BP, Ferraz CC, Vianna ME, Berber VB, Teixeira FB, Souza-Filho FJ. In vitro antimicrobial activity of several concentrations of sodium hypochlorite and chlorhexidine gluconate in the elimination of *Enterococcus faecalis*. *Int Endod J.* 2001;34:424-428.
36. McBain AJ, Bartolo RG, Catrenich CE, Charbonneau D, Ledger RG, Gilbert P. Effects of a chlorhexidine gluconate-containing mouthwash on the vitality and antimicrobial susceptibility of in vitro oral bacterial ecosystems. *Appl Environ Microbiol.* 2003;69:4770-4776.
37. Ainamo J. Control of plaque by chemical agents. *J Clin Periodontol.* 1977;4:23-35.