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SYSTEMATIC REVIEW

Comparative anti-plaque and anti-gingivitis efficiency of Triphala versus chlorhexidine mouthwashes in children: a systematic review and meta-analysis

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Abstract

The aim of this systematic review is to comparatively evaluate the Triphala and chlorhexidine mouthwashes efficacies in decreasing plaque formation and gingivitis in children. With a priori-set inclusion and exclusion criteria's and relevant MeSH terms, the PubMed, Cochrane and Ovid SP were scrutinized from the year 1980 to April 2023 for prospective articles. Outcomes evaluated were plaque formation and gingivitis through Plaque index and Gingival index. Five studies were finally included and were analyzed qualitatively and quantitatively. Meta-analysis, was performed using a random effects model. Plaque index (PI) and Gingival Index (GI). There was no significant difference between reduction in the gingivitis and plaque accumulation between Triphala and chlorhexidine mouthwash groups in children (*p* value 0.83, 0.96).

Keywords

Adults; Adolescents; Children; Chlorhexidine; Herbal; Mouthwash; Triphala

1. Introduction

Periodontal health is a good indicator of general health. Poor periodontal health can be associated with several systematic disorders such as diabetes mellitus (type-2) [1], cardiovascular disorders [2],chronic renal diseases [3],respiratory disorders [4]. Gingivitis and plaque formation are diagnostic indicators of periodontitis [5, 6]. Plaque bio film formation can induce varying degrees of gingival inflammation depending on the host response. Plaque control is a primordial way to prevent the development of gingival inflammation and periodontal disease. Chemical plaque control methods should always compliment mechanical plaque control methods [7–9]. Among chemical methods, chlorhexidine mouthwash has been stated as a "benchmark standard" for its effectiveness against plaque formation and gingival inflammation [10–13]. Multiple studies and systematic reviews reporting the positive effect of herbal mouthwashes for its beneficial effects on plaque, gingivitis action have been published in the literature. Various herbal agents such as Salvadora persica [14], Camellia sinensis [15, 16], Azadirachta indica [17], Curcumin [18, 19], Propolis [20], Aloe vera [21], have reported to have a comparable antiplaque and antigingivitis efficacy in comparison to chlorhexidine mouthwashes. Few systematic review and meta-analysis compared herbal mouthwashes to that of Chlorhexidine mouthwashes and reported comparable effects in terms of antiplaque and antigingivitis effect [22–27]. Triphala, on the other hand, has not gained popularity until recent years in dental literature, but the health benefits of Triphala was mentioned hundreds of years ago in ancient Indian ayurvedic literature. Triphala is composed of a combination of three herbal products, viz., *Terminalia chebula*, *Terminalia bellirica* and *Embilica officinalis* [28]. Many of the studies reported positive effects of Triphala mouthwashes on plaque and gingivitis control [29]. The knowledge gap exists about the true efficacy of Triphala when compared to chlorhexidine. One narrative review was found on Triphala but it did not pool the results for meta-analysis [29–32].There was no studies exclusively to evaluate

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the effect of Triphala extract based mouthwashes on antiplaue and antigingivitis efficacy oin children and also no meta-analysis comparing Triphala to Chlorhexidine mouthwashes in children has been performed to the best of our knowledge and hence this systematic review and meta-analysis was carried out to investigate the comparative efficacy of the two mouthwashes Triphala and Chlorhexidine in reducing plaque formation and gingival inflammation among children.

2. Materials and methods

2.1 Search strategy

Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines are used in the reporting of this study. Prospero registration was performed (CRD42023428391). Population, Intervention, Comparison and Outcome (PICO) framework was the search strategy rooted on the question: "*Comparison of Triphala and chlorhexidine mouthwashes in reducing gingival and plaque scores clinically in children*". Parameters under PICO include: Patient/Population (P): Children under the age of 18 years; Intervention (I): any concentration of Triphala extract diluted to be utilized as a mouthwash; Comparison (C): chlorhexidine mouthwash alone; Outcome (O): plaque accumulation, gingival status. PubMed, Ovid SP, Cochrane was the three databases where electronic search was performed based on the priori-set question and by using relevant MeSH terms: (Triphala) AND ((mouthwash) OR mouth rinse). Articles published until April 2023 in English language were included.

2.2 Criteria for study selection

In-vivo studies in which any concentration of Triphala extract diluted to be used as a mouthwash and compared with chlorhexidine in mouthwash were only included. Studies with a minimum usage of mouthwash for 2 weeks or more are only included. *In-vitro* studies, studies where the duration of usage of mouthwash is less than 2 weeks are excluded. Studies on the use of mouthwashes in fixed or removable orthodontic patients were also excluded. The studies excluded were case reports, comparative studies, narrative and systematic reviews and also the articles that could not be converted to English language.

2.3 Data extraction

Following the extensive MeSH terms search in all the databases, the obtained studies were hand searched. The duplicate studies were excluded and the titles and abstracts screening were accomplished. Then the prospective articles were incorporated for complete review. Subsequently, two independent reviewers performed the data extraction and data analysis and recorded it on Microsoft excel sheet. The author details, publication year, subject age, total number of participants in the study, intervention employed and its duration, comparison parameters and outcome variables were the information extracted and entered on the data form. The plaque score, gingival inflammation and *S. mutans* count were the outcome measures of interest. From the individual studies means and Standard Deviations (SD) were also extracted. A meta-analysis was carried out to address the review question for all three outcome variables. Combined results were presented as a pooled mean difference and estimated using fixed and random-effect models. A 5% statistical significance level was considered. In the occurrence of heterogeneity (chi-square $p < 0.05$ or I^2 index $>50\%$), the random-effect model was considered [33]. Two independent review team members assessed for the included articles' methodological quality using the Cochrane Collaboration's criteria. To analyse the quality of all the selected study trials, the risk of bias (RoB) assessment was done using the seven domains.

3. Results

3.1 Types of studies included

419 records were found in all the databases, of which 8 articles were duplicates. Eliminating these duplicates, 411 records were further assessed by their title and abstract. Complete script of the 29 probable pertinent papers were retrieved,amongst them 24 studies were excluded. The reasons for excluding particular articles are specified in the Fig. 1, Table 1 [34–49]. Consequently, five studies were included in this study [50–54]. A flowchart of the search results is presented in Fig. 1.

3.2 The characteristics of included studies

The attributes of the included studies are illustrated in Table 2. Studies are published between the years 2011 to 2021. In the included studies, children's age ranged from 8 to 15 years. The concentration of Triphala mouthwash used ranged from 0.4 to 10%, most frequently used concentrations were 0.4–0.6% [49, 52], 6% [50, 53], 10% [51]. Duration of mouthwash study period across all the studies included: two weeks [50, 53], one month [51],three months [52], 9 months [49]. Once-daily mouthwash regimen was followed only in two studies [49, 51, 53] and in the two studies, twice daily mouthwash regimen was used [50, 52]. Chlorhexidine mouthwash was used in the concentration of 0.12 to 0.2% in the selected studies. All the five included studies used Triphala and chlorhexidine mouthwashes and all these studies measured plaque scores [49–53].

3.3 Risk of bias

Risk of bias was evaluated using Cochrane collaboration RoB2 criteria [54]. Randomization and allocation concealment was specified in all the included studies, bias due to deviations from intended interventions, missing data and bias in the measurement of outcome was not reported in any of the included studies (n = 5). Outcome evaluation was not mentioned clearly in any of the included studies. Selective reporting bias and other bias was not present in any of the study mentioned. Overall the bias of all the included studies can be rated as with some concerns (Fig. 2).

3.4 Qualitative and quantitative analysis

All the studies were included for qualitative analysis [49–53]. Only 4 studies were included for meta-analysis [49–52]. The

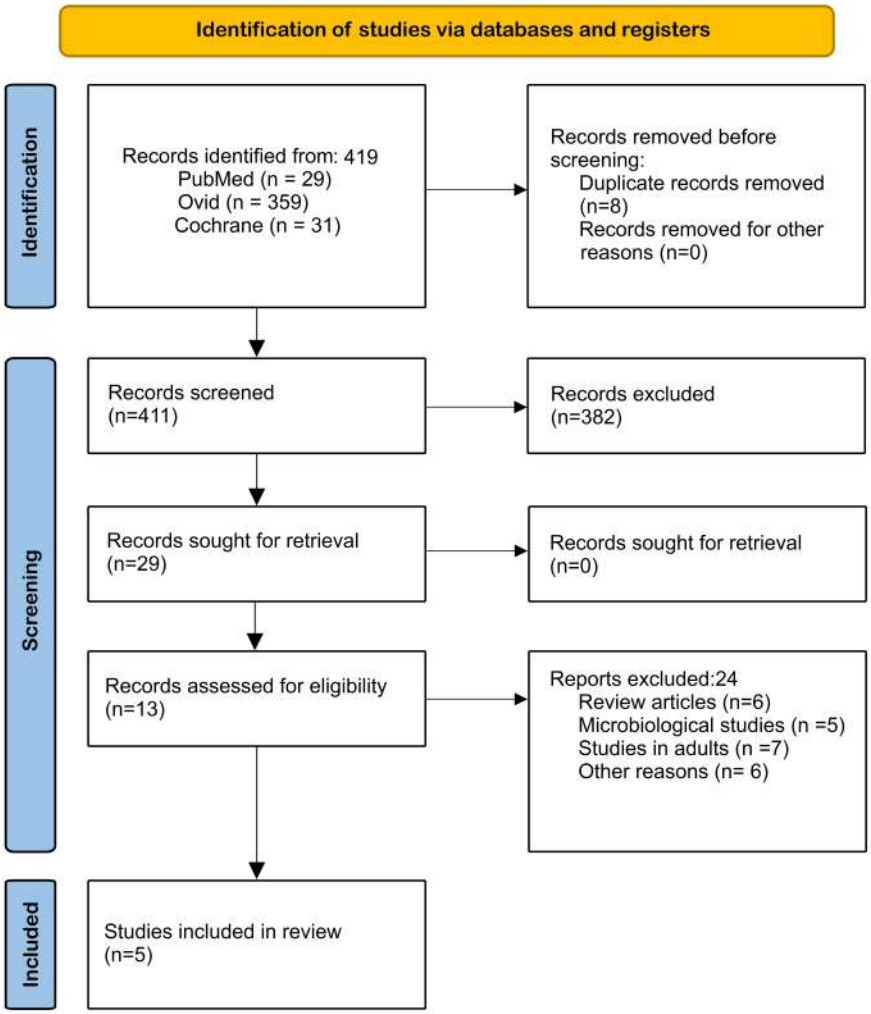

FIGURE 1. Flow chart in PRISMA format.

TABLE 1. showing excluded articles and reasons for exclusion.

Sno	Excluded articles	Reasons for Exclusion
1	Ramachandran 2022 [34]	Microbiological study
2	Deshpande 2022 [35]	Microbiological study, Triphala tooth wipes in special children
3	Laleman and Teughels 2020 [36]	Review article
4	Al Jameel and Almalki 2020 [37]	Review article in Adults
5	Penmetsa 2019 [38]	Study in Adults
6	Naiktari 2018 [39]	Study in Adults
7	Baratakke 2017 [40]	Study in Adults
8	Saxena 2017 [41]	Microbiological study
9	Mamgain 2017 [42]	Adults
10	Pradeep 2016 [43]	Adults
11	Prabhakar 2014 [44]	Microbiological study
12	Naiktari 2014 [45]	Adults
13	Srinagesh 2012 [48]	Adults
14	Narayan and Menden 2012 [47]	Plaque formation in adults
15	Srinagesh and Pushpanjali 2011 [46]	Microbial study in adults
16	Tandon 2010 [49]	Anticaries efficacy in children

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TABLE 2. Characteristics of included studies.

Sno	Author-Year	Age	Number	Duration of intervention	Intervention	Plaque index	Gingival index	Microbial count	Results
1.	Bhattacharjee, 2014 [50]	8–12	60 children divided into two groups	Twice daily for 14 days	Group 1: 6% Triphala Group 2: 0.12% Chlorhexidine	Yes	Yes		Triphala comparable to chlorhexidine in gingival inflammation scores. Plaque scores better with chlorhexidine
2.	Chainani, 2014 [51]	13–16	120 divided into three groups	Once daily for thirty days	Group 1: Placebo Group 2: 0.12% Chlorhexidine Group 3: 10% Triphala	Yes	Yes		Triphala comparable to chlorhexidine
3.	Bajaj, 2011 [49]	8–12	1431 divided into three groups	Once daily for 9 mon	Group 1: 0.6% Triphala Group 2: 0.1% Chlorhexidine Group 3: control	Yes	Yes		Triphala comparable to chlorhexidine
4.	Bhor, 2021 [52]	14–15	72 children were divided equally into two groups	Twice daily for 3 mon	Group 1: 0.4% Triphala mouth rinse Group 2: 0.12% Chlorhexidine mouth rinse	Yes	Yes	Yes	Triphala (0.4%) and Chlorhexidine (0.12%) mouthwash showed a similar trend in preventing plaque formation and in anti-inflammatory effect on gingival health with no evident side effects after 90 days of use
5.	Padiyar, 2018 [53]	9–12	60 children were randomly divided into three groups	Once a day for 15 days	Group 1: 6% Triphala mouthwash Group 2: 0.2% Chlorhexidine mouth rinse	Yes	No	Yes	Chlorhexidine was more efficient

study by Padiyar *et al.* [54] 2018 was excluded from meta-analysis as data was not presented clearly.

3.5 Gingival Inflammation

The gingival condition in all the included studies were evaluated both at baseline and post-intervention subsequent follow-up visit with Loe and Silness Gingival index (GI). Meta-analysis for outcome gingival index was performed. Baseline and post-intervention scores were evaluated in both the mouthwash groups: Triphala and chlorhexidine. There was a statistically significant reduction in GI scores at post-intervention in comparison at baseline (p value = 0.001, Mean Difference: 0.61, 95% Confidence Interval range: 0.24–0.99) in Triphala mouthwash group. Similarly, in Chlorhexidine mouthwash group there was a significant reduction of GI scores at post-intervention in comparison at baseline (p value = 0.01, Mean Difference: 0.57, 95% Confidence Interval: 0.12–1.01). However, both Triphala and Chlorhexidine mouthwash groups did not exhibit any statistically significant differences with respect to gingival index scores (p value = 0.83) (Fig. 3).

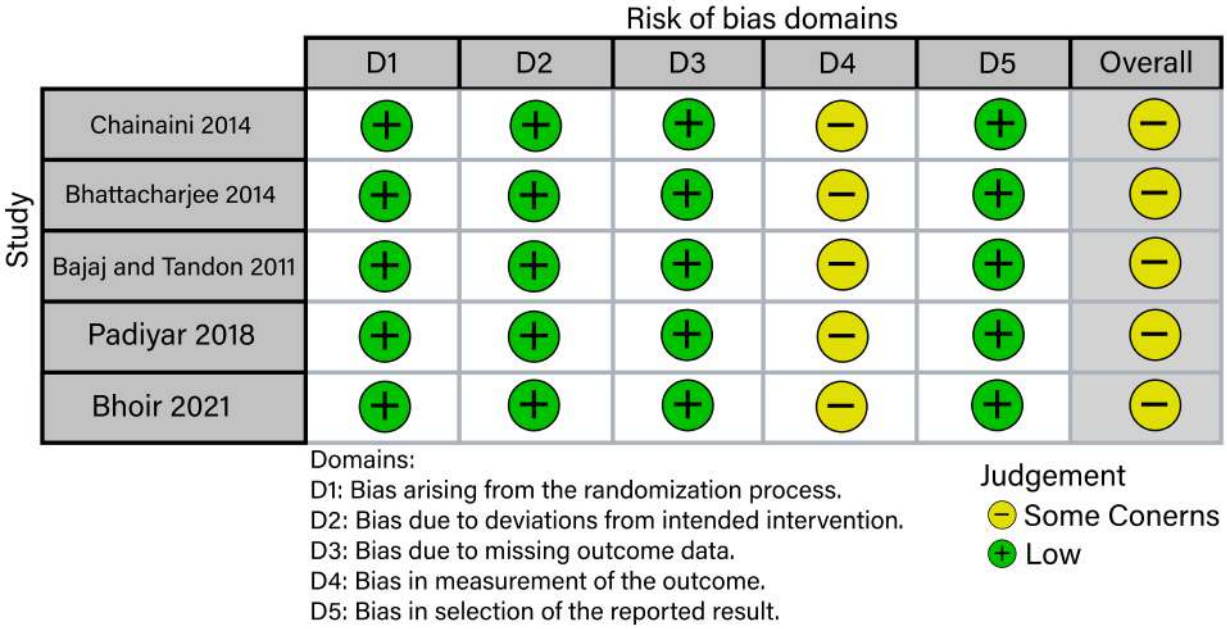

FIGURE 2. Risk of bias in the included studies.

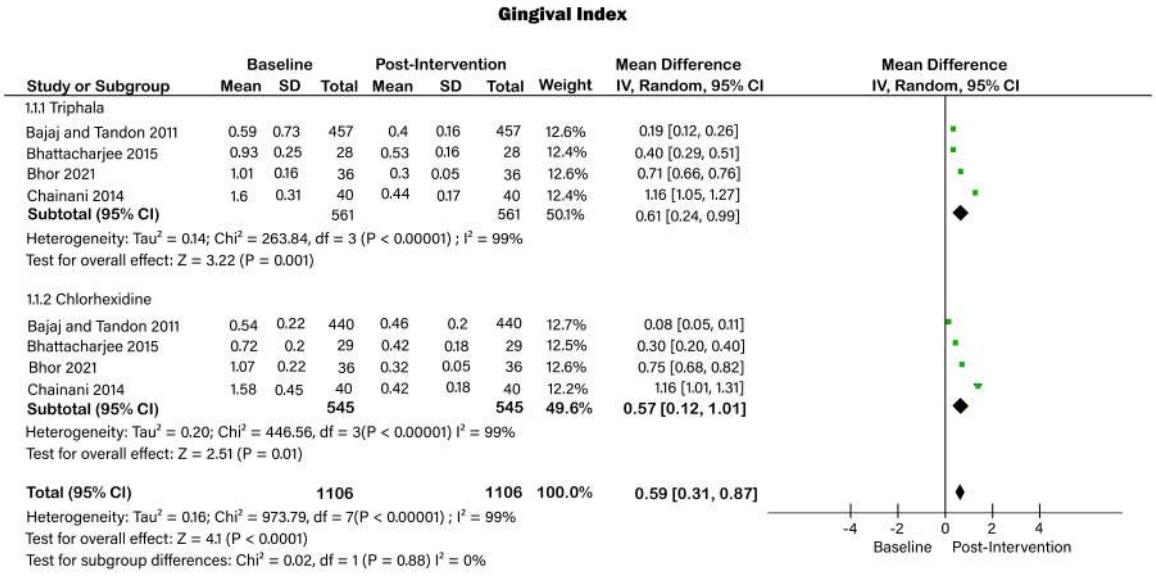

FIGURE 3. Forrest plot of gingival index. SD: standard deviation; CI: confidence Interval.

3.6 Plaque index

Plaque index (PI) was used to assess the plaque score at baseline and follow up visit of all included studies. Meta-analysis for the outcome plaque index was performed. Baseline and post-intervention plaque scores were evaluated in both mouthwash groups. There was a statistically significant decline in PI scores in comparison to baseline with Triphala mouthwash (p value = 0.0001, Mean Difference: 0.66, 95% Confidence Interval: 0.35 to 0.97). Also, when post-intervention scores were compared to baseline there was a statistically significant decline in PI scores in Chlorhexidine mouthwash group (p value = 0.0001, Mean Difference: 0.67, 95% Confidence Interval: 0.23 to 1.12). However, in terms of plaque index scores, no statistically significant differences were noticed between the Triphala and chlorhexidine mouthwash groups (p value = 0.96) (Fig. 4).

4. Discussion

Plaque accumulation occurs more rapidly in children in the primary and mixed dentition than in adults [55]. Dental plaque accumulation can lead to gingivitis, and indirectly can lead to caries formation. Dental plaque induced gingival inflammation is more common in all the age groups, including children [56]. Plaque reduction is achieved primarily by mechanical methods such as toothbrushing [57]. In children the main factors responsible for limiting the effectiveness of mechanical toothbrush aided plaque removal are, lack of motivation of brushing, incorrect toothbrushing technique, under-developed manual dexterity, *etc*. [52, 58–60]. Mouth rinse is an adjunctive method, along with toothbrushing to improve the oral hy-

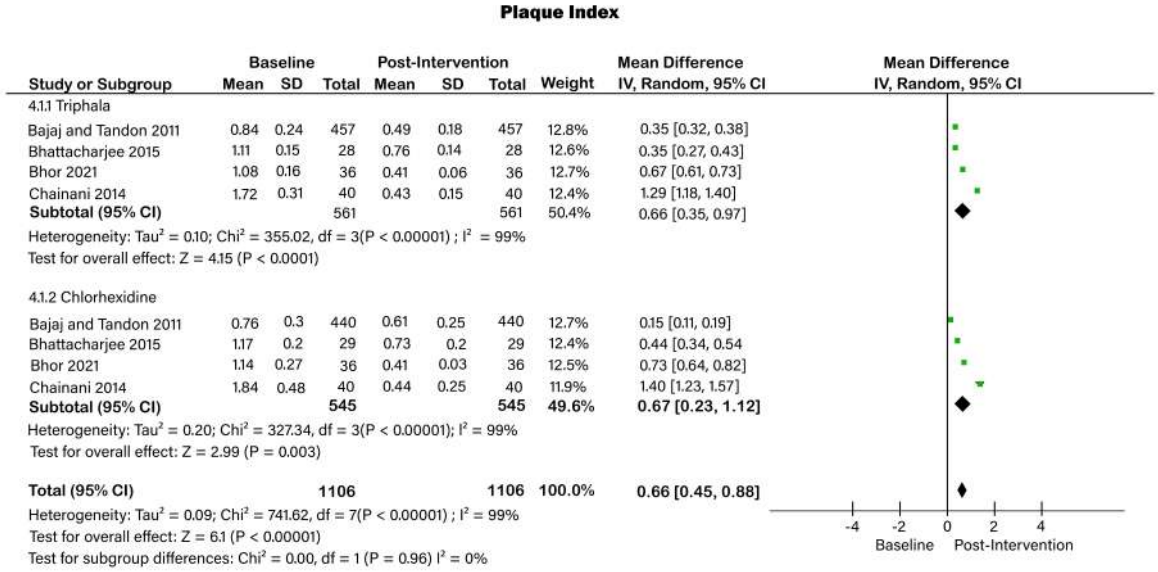

FIGURE 4. Forrest plot of plaque index. SD: standard deviation; CI: confidence Interval.

giene [61, 62]. The key role in improving the health of the periodontium is by keeping a check on plaque accumulation and gingival inflammation. Chlorhexidine mouthwash is already proven to reduce gingivitis in children [63]. Chlorhexidine is a "benchmark standard" mouthwash, its inhibitory effects on plaque formation and gingival inflammation has already been established in many studies. A systematic review on chlorhexidine, reported the anticaries efficacy when used as a varnish or gel in children and adolescents [64]. Chlorhexidine as a mouthwash is used in the concentrations of 0.12 to 0.2% in the included studies. The main disadvantages of long-term usage of chlorhexidine can cause after effects like staining of teeth, discoloration of pre-existing restorations, dysgeusia, altered taste sensation, burning sensation on the tongue, ulceration, sloughing off of the oral mucosa, supragingival calculus formation [65–67]. Researchers are working on various herbal mouthwashes such as aloe vera, tea tree oil, green tea mouthwash, neem and mango leaf extracts, *etc*. [68–70]. Studies have proven that Triphala mouthwash is effective in reducing the plaque accumulation as well as plaque induced gingivitis in children [51, 53]. Triphala, an age-old ayurvedic medication, and a combination of three herbal extracts ("*Emblica officinalis*, *Terminalia chebula* and *Terminalia bellerica*") is gaining popularity in recent times as an increasing number of studies show promising results with the same. In dentistry Triphala exhibited a range of actions such as anti-oxidant, anti-cavity and it's a potent antimicrobial agent as well. The main advantage of Triphala is it does not have any side effects even after long term usage and it can be used safely in all the age groups. This systematic review and meta-analysis study assessed the comparative efficacy of the mouthwashes Triphala and chlorhexidine in reducing plaque formation and gingival inflammation in children. In all the included studies Triphala mouthwash was prepared by the authors, no commercial preparations were used. Five studies were included for qualitative analysis, out of which four studies were included for quantitative analysis. Random-effects model was followed as heterogeneity was more in the included studies.

4.1 Plaque index

Plaque index was measured in the all studies with Sillness and Loe index. Results of this current systematic review and meta-analysis report that when post-intervention and baseline data were compared for plaque index scores, there was significant decrease in the plaque accumulation in both Triphala and chlorhexidine mouthwash group irrespective of their concentration, duration and administration methods, no statistically significant difference between the Triphala and chlorhexidine mouthwash groups was noticed in children.

4.2 Gingival index

Gingival index was measured in the all studies with Loe and Sillness index. Results of this current systematic review and meta-analysis report that when post-intervention and baseline data were compared for gingival index scores, there was significant decrease in the gingivitis in both Triphala and chlorhexidine mouthwash group irrespective of their concentration, duration and administration methods, no statistically significant difference between the Triphala and Chlorhexidine mouthwash groups was noticed in children.

4.3 Limitations and direction for future research

Concentrations of mouthwashes, duration of mouthwash usage, differed across the included studies. As there were inadequate number of studies available, sub-grouping based on concentrations, duration of usage was not possible. Other parameters such as bleeding index, *S. mutans* count, halitosis were not mentioned in all the studies so we have excluded those parameters for systematic review and meta-analysis. Evaluating these parameters when more studies are available will be an interesting area for future research. Also, substantivity is a well-known property of chlorhexidine, evaluation

of substantivity properties of Triphala (if any), and comparing it to that of chlorhexidine will also be a riveting subject for the future research. Also, comparing the efficacy of these two mouthwashes in established gingivitis and periodontitis will be a remarkable area for futuristic research.

5. Conclusions

Within the limitations of this systematic review and meta-analysis, low-quality evidence indicates that the anti-plaque and ant-gingivitis efficacy of the mouthwashes Triphala is comparable to Chlorhexidine. Also, more high-quality studies with ample sample size and extended duration are needed to validate the same.

AVAILABILITY OF DATA AND MATERIALS

Not applicable.

AUTHOR CONTRIBUTIONS

ST—designed, analyzed and wrote the manuscript. LA—has contributed to the data analysis. MMM, GM—has contributed to data collection. MDB, GI, GC, MC—revised the manuscript. All authors contributed to editorial changes in the manuscript. All authors read and approved the final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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