



ORIGINAL ARTICLE

EVALUATION OF THE ANTIFUNGAL EFFICACY BETWEEN DIFFERENT ESSENTIAL OILS INCORPORATED INTO DENTURE SOFT LINERS- A SYSTEMATIC REVIEW AND META-ANALYSIS

Sakshi Dumbre¹, Hema Kanathila² Shetty Hardik Santosh³, Ranjith Shetty⁴, Deepthi Adappa⁵ Rahul Bhandary⁶, Khushi Shukla⁷¹Postgraduate student, Department of Prosthodontics Crown and Bridge, KAHERs KLE VK Institute of Dental Sciences, Belgaum, Karnataka. E-Mail: dumbresakshi29@gmail.com²Professor Dept. of Prosthodontics Crown and Bridge, KAHERs KLE VK Institute of Dental Sciences, Belgaum Karnataka E-Mail: hema_kanathila@yahoo.com³Associate Professor, Dept of Oral and Maxillofacial Surgery, Sharavathi Dental College and Hospital, Shivamogga, Karnataka. E-Mail: drhardikshetty@gmail.com⁴Senior Lecturer Dept of Oral and Maxillofacial Pathology, A.B Shetty Memorial Institute of Dental Sciences, NITTE (Deemed to be University), Derlakatte, Mangalore, Karnataka. E-Mail: dranjith.shetty@nitte.edu.in⁵Senior Lecturer Department of Oral Medicine and Radiology, Yenepoya Dental College, Mangalore, Karnataka E-Mail: deepthiadappa@hotmail.com⁶Professor Dept. of Periodontology, A B Shetty Memorial Institute of Dental Sciences, Mangalore, NITTE(Deemed to be University),Derlakatte, Karnataka E-Mail: drrahulbhandary@nitte.edu.in⁷Postgraduate Student Dept. of Periodontology, A B Shetty Memorial Institute of Dental Sciences, NITTE Deemed to be University, Derlakatte, Mangalore, Karnataka E-Mail: khushishukla0598@gmail.com***Corresponding Author: Dr Hema Kanathila** Professor Dept. of Prosthodontics Crown and Bridge, KAHERs KLE VK Institute of Dental Sciences, Belgaum, Karnataka E-Mail: hema_kanathila@yahoo.com**Received:** Jul 27, 2025; **Accepted:** Aug 28, 2025; **Published:** Oct 20, 2025**Purpose:** The purpose of this systematic review is to evaluate the antifungal efficacy of different essential oils (EO) incorporated into denture soft liners compared to conventional denture soft liners.**Materials and Methods:** The review adhered to Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) 2020 guidelines and was registered in PROSPERO (CRDXXXX). A thorough search of databases was conducted from January 2000 to September 2024 in PubMed, google scholar and EBSCO host to retrieve articles in the English language for comparative, in vitro and cross-sectional studies comparing essential oils incorporated into denture soft liners against *C. albicans* compared to conventional denture soft liners. Quality assessment was performed using Cochrane risk of bias (ROB) -2 tool through Review Manager (RevMan) software version 5.3.**Results:** Through search strategy a total of 39 articles were yielded. After screening titles and abstracts, 17 articles were further screened for full text. After critical analysis, according to the eligibility criteria of this review, 6 articles were included in this systematic review for data extraction. Six studies underwent qualitative synthesis and three studies for meta-analysis. Upon quality assessment, the studies demonstrated a range of moderate to low risk of bias. Meta-analysis showed that essential oils showed better zone of infection (ZOI) (SMD = 4.84 (2.14 – 7.53) and reduced surface roughness (SMD = -50.85 (-157.15 – 55.44). Funnel plot did not show any presence of possible publication bias in meta-analysis ($p < 0.05$).**Conclusion:** The study concluded that the addition of essential oils into denture soft tissue liners improved the overall antifungal property, provided large cushioning effect with reduced damage to oral tissue and had shown more superior and effective results than systemic/natural agents.**Keywords:** antifungal efficacy, candida albicans, denture soft liners, essential oils

INTRODUCTION

Candida species are involved in most of the infections. Candida albicans is an opportunistic microbe comprising 40% to 80% of the microbial flora of healthy individuals and is responsible for causing 50% to 90% of human candidiasis.¹

Candida albicans is most commonly associated with denture stomatitis along with other causative factors of poor oral hygiene, ill-fitting denture, trauma from occlusion, and existing fungal infections.² A steep rise in deep fungal infections has been observed for over two decades, not only

in patients with compromised immunity but also in healthy population.³

Soft lining materials like tissue conditioners, are used in various clinical treatments, such as relieving inflamed tissue, covering sharp atrophic ridges and improving denture fitting.⁴ Tissue conditioners encounter some problems such as loss of softness, water sorption, and adhesion failure.⁵ They are prone to microbial accumulation, which typically includes *Candida albicans*, *Staphylococcus aureus* and *Streptococcus mutans*.⁶ Moreover, the aging tissue conditioner becomes more favorable for the colonization of *C. albicans* adherence to the soft liner and penetrating the material, and aggravating the denture stomatitis.⁷

Antimicrobial additives have been incorporated into soft lining materials as a drug delivery vehicle to improve the material properties and treatment effectiveness.⁸ Well-established studies have been carried out to incorporate antifungal agents into tissue conditioners with excellent antifungal effects for denture stomatitis.⁹ Various substances, including nystatin, azole drugs, metallic oxide particles and natural products, have been chosen to combine in soft lining materials.¹⁰ Incorporation of different antifungal agents such as chlorhexidine, fluconazole, nystatin, and ketoconazole has been conducted with effective variable durations depending on the antifungal agent used and tissue conditioners.¹¹ However, using topical antifungal agents may be associated with a few unwanted effects, such as objectionable taste and the need for frequent applications. Due to the increase in antibiotic resistance and toxicity, alternative, naturally derived additives are considered as great alternative for such materials.

The major advantages of natural medicinal plant extracts as antimicrobial agents include enhanced safety and stability without side effects. Among the reported essential oils, anti-*Candida* activity was shown by mint, basil, lavender, tea tree oil, peppermint, and geranium essential oil. The EO affected mainly the cell wall and the membranes of *C. albicans* and caused changes in colony morphotypes and metabolic activities.¹²

Going through evidences, till date no study has provided a comprehensive, quantitative analysis of the effect of essential oils on anti-fungal properties of denture soft liners. Therefore, this study conducted a systematic review with the aim to assess, evaluate and compare the effectiveness of different essential oils incorporated into denture soft liners compared to conventional denture soft liners through a novel meta-analysis.

Materials and Methods

Protocol development

This review was conducted and performed in according to the preferred reporting items for systematic review and meta-analysis (PRISMA) 2020 statement¹³ and registered in Prospective Registration of Systematic Review (PROSPERO)- CRDXXXX.

Study design

The following focused research question in the Participants (P), Intervention (I), Comparison and Outcome (O) format was proposed “What is antifungal effect of various essential oils when incorporated in denture soft liners.

The PICO criteria for this review were as follows:

P (Participants) – Patient with denture soft liner prosthesis

I (Intervention) – Various essential oils incorporated into denture soft liners against *C. albicans*

C (Comparison) – Conventional denture soft liners

O (Outcome) – To assess the antifungal effect of various essential oils in terms of increase in zone of inhibition (ZOI) and decrease in surface roughness

S (Study designs) – Randomized Clinical Trials (RCTs), comparative studies, prospective studies, retrospective studies, in vitro studies

Eligibility Criteria: Studies were selected based on following criteria's

a) Inclusion Criteria: Following were the inclusion criteria

- 1) Articles published in English language
- 2) Articles having sufficient comparative data on various essential oils incorporated into denture soft liners against *C. albicans* compared to conventional denture soft liners
- 3) Studies published between January 2000 – September 2024 and having relevant data on increase in zone of inhibition (ZOI) and decrease in surface roughness
- 4) Randomized controlled trials (RCTs), comparative studies, prospective studies and in vitro studies were taken into consideration
- 5) Articles from open access journals
- 6) Articles reporting the study outcomes in terms of frequency, mean and standard deviation

b) Exclusion Criteria: following were the exclusion criteria

- 1) Any studies conducted before 2000
- 2) Articles in other than English language

- 3) Reviews, abstracts, letter to the editor, editorials, animal studies were excluded
- 4) Articles not from open access journals
- 5) Articles not reporting the study outcomes in terms of mean and standard deviation

Search Strategy

A comprehensive electronic search was performed till September 2024 for the studies published within the last 24 years (from 2000 to 2024) using the following databases: PubMed, google scholar and EBSCO host to retrieve articles in the English language. The searches in the clinical trials database, cross-referencing and grey literature were conducted using Google Scholar, Grey list and Open Grey.

Appropriate key words and Medical Subject Heading (MeSH) terms were selected and combined with

Boolean operators like AND. The relevant data was searched using the following keywords and their combinations: “denture soft tissue liners” (MeSH term) AND “essential oils” (MeSH term); “antimicrobial effect” (MeSH term) AND “antibacterial effect” (MeSH term); “zone of inhibition” (MeSH term) AND “diameter of inhibition zone” (MeSH term) AND “decreased inhibitory zone” (MeSH term); “surface roughness” (MeSH term) AND “in vitro study” (MeSH term) AND “prospective study” (MeSH term); “randomized trials” AND “retrospective study” (MeSH term).

In addition to the electronic search, a hand search was also made, and reference lists of the selected articles were screened. The reference lists of identified studies and relevant reviews on the subject were also scanned

Search Strategy according to PICO Format:

	Strategy
Population	("denture soft tissue liners"[MeSH Terms] OR "tissue conditioners" OR "abused oral tissue" OR ("candida albicans"[MeSH Terms] OR ("antifungal efficacy"[MeSH Terms]
ntervention	("essential oils"[MeSH Terms] AND “minimal inhibitory concentration” AND ("zone of inhibition"[MeSH Terms] OR "surface roughness" OR ("tensile strength"[MeSH Terms] OR "viscoelasticity"
Comparator	onventional denture soft liners"[MeSH Terms] OR “traditional denture soft liners” AND “minimal inhibitory concentration” AND ("zone of inhibition"[MeSH Terms] OR "surface roughness" OR ("tensile strength"[MeSH Terms] OR "viscoelasticity"
Outcome assessed	("zone of inhibition"[MeSH Terms] OR "surface roughness" OR ("tensile strength"[MeSH Terms] OR "viscoelasticity" AND "in vitro study" AND "randomized controlled trial" AND "comparative study"

Screening process

Search and screening were done by two authors. The process of choosing of articles was divided into two phases. Two reviewers looked over the titles and abstracts of every article in first round. Articles that didn’t fit into the inclusion were removed. Phase-two, involved independent screening and review of few full papers by the same reviewers. Discussions were held to settle by any disputes. A third reviewer was bought in to make the ultimate decision when two reviewers could not agree upon something. All three authors came to agreement on choice in the end.

Data extraction

For all included studies, following descriptive study details were extracted by two independent reviewing authors and using pilot-tested customized data extraction forms in Microsoft excel sheet with the following headings included in the final analysis: author(s), country of study, year of study, study design, sample size, modalities used, outcome evaluated, parameters assessed, follow up duration and conclusion.

Quality assessment of included studies

The methodological quality among included studies was executed by using Cochrane collaboration risk of bias (ROB) -2 tool¹⁴. The tool has various domains like random sequence generation (selection bias), allocation concealment (selection bias), blinding of personnel and equipments (performance bias), blinding of outcome assessment (detection bias), incomplete outcome data (attrition bias), selective reporting (reporting bias) and other biases through their signalling questions in Review Manager (RevMan) 5.3 software. The overall risk for individual studies was assessed as low, moderate or high risk based on domains and criteria. The study was assessed to have a low overall risk only if all domains were found to have low risk. High overall risk was assessed if one or more of the six domains were found to be at high risk. A moderate risk assessment was provided to studies when one or more domains were found to be uncertain, with none at high risk.

Statistical analysis

The standardized mean difference (SDM) with 95% CI was calculated for continuous outcomes. A fixed effects model (Mantel-Haenszel method) was used if there was no heterogeneity (p >0.05 or I-squared ≤24%), otherwise a random effects model (Der Simonian- Laird method) was used.¹⁴ All statistical analyses were performed

using the RevMan 5.3 (Cochrane Collaboration, Software Update, Oxford, UK). The significance level was kept at $p < 0.05$.

Assessment of heterogeneity

The significance of any discrepancies in the estimates of the treatment effects of the different trials was assessed by means of Cochrane's test for heterogeneity and the I^2 statistics, which describes the percentage of the total variation across studies that is due to heterogeneity rather than chance. Heterogeneity was considered statistically significant if $P < 0.1$. A rough guide to the interpretation of I^2 given in the Cochrane handbook is as follows: (1) from 0 to 40%, the heterogeneity might not be important; (2) from 30% to 60%, it may represent moderate heterogeneity; (3) from 50% to 90%, it may represent substantial heterogeneity; (4) from 75% to 100%, there is considerable heterogeneity.¹⁵

Investigation of publication bias

To test for the presence of publication bias, the relative symmetry of the individual study estimates was assessed around the overall estimates using Begg's funnel plot. A funnel plot (plot of the effect size versus standard error) was drawn. Asymmetry of the funnel plot may indicate publication bias and other biases related to sample size, although asymmetry may also represent a true relationship between trial size and effect size.¹⁶

RESULTS

Study Selection

After evaluation, reference rundown of all included examinations was done. Out of which 35 examinations were eliminated. After this, full text articles were evaluated for qualification and articles that didn't meet consideration rules were barred. Only six studies fitted into inclusion criteria and were subjected to qualitative analysis and three studies for meta-analysis as shown in **Figure 1**

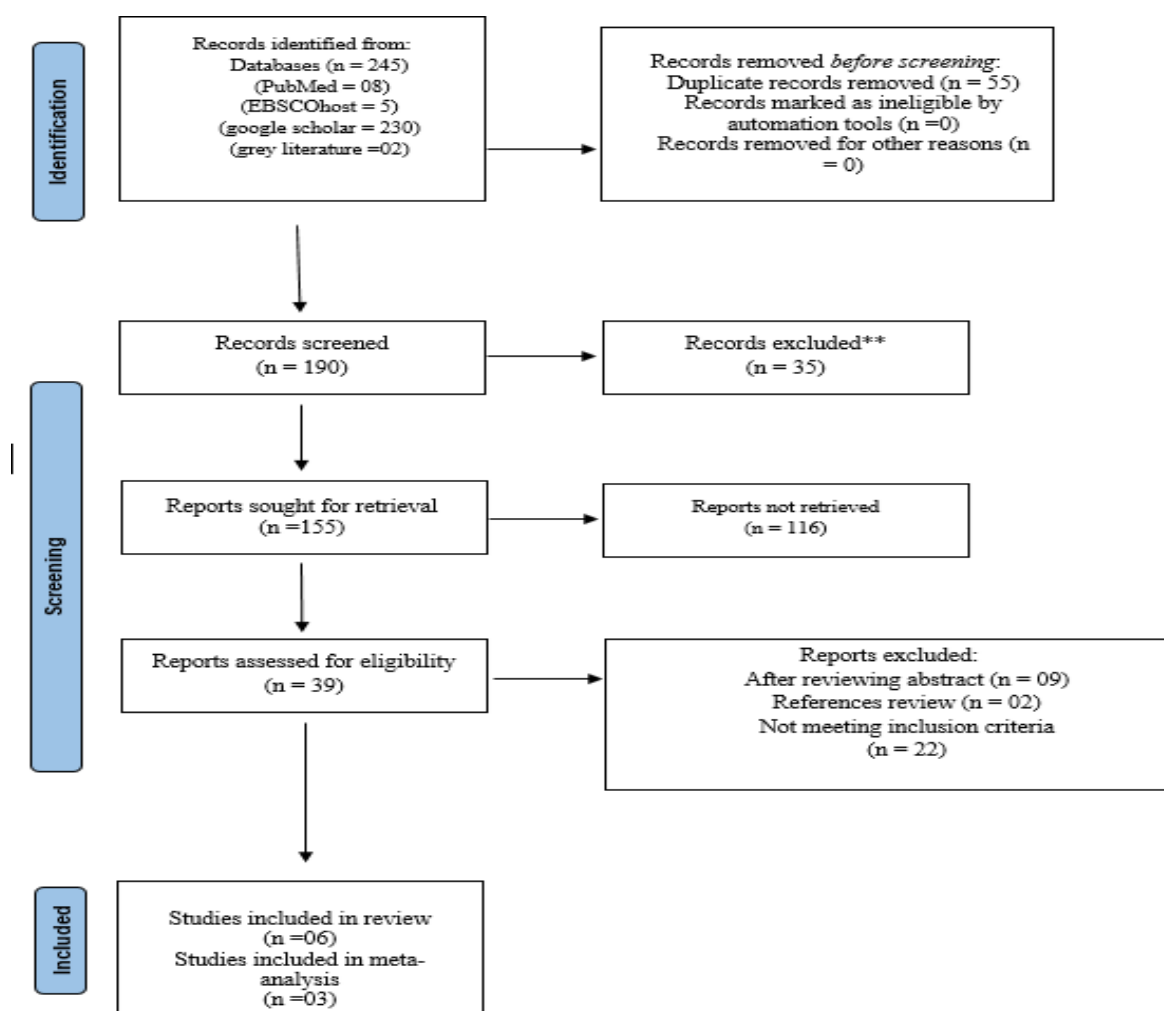


Figure 1. PRISMA 2020 Flow Diagram

As shown in **Table 1**, data was evaluated from six studies¹⁶ from an aggregate of total of 235 sample size (denture soft tissue liners) on which the efficacy of various essential oil (EO) at various concentrations was assessed and evaluated in terms of increase in zone of inhibition (ZOI) and decrease in surface roughness against *C. albicans* and *S. aureus*. All the included studies had in vitro study design. Among the included studies, three studies were conducted in India and one study in Iraq¹⁷, Switzerland²⁴ and Singapore each¹⁸. Various essentials oils evaluated for were *C. anthelminticum*, *Ocimum sanctum* Linn, and *Li num usitatissimum*, oregano oil and virgin coconut oil, *Litsea cubeba* essential oil (LCEO (10%, 30%), lemon grass essential oil (LGEO), *Lawsonia inermis*, *Withania somnifera* (1%, 3%, 5%, 7%) and *Ocimum*

Table 1. Descriptive study details of included studies

Author, years of study	Country	Sam ple size (n)	Essential oils (EO) used	Outcomes assessed	Parameters evaluated	Conclusion
Muttagi et al., 2017 ²¹	India	15	<i>C.anthelminticum</i> , <i>Ocimum sanctum</i> Linn, and <i>Li num usitatissimum</i>	To evaluate the antifungal properties of various EO against <i>C. albicans</i>	ZOI (24, 48, 72 hrs and 7 days) and surface roughness	Addition of EO improved the overall antifungal property and reduced surface roughness
Rawat et al., 2017 ²²	India	40	Systemic/natural antifungal agents - Fluconazole, Natural oregano oil and virgin coconut oil	To compares anti-fungal property and mechanical properties of tissue conditioner containing different antifungal agents.	ZOI (24, 48 and 7 days)	Adding natural agents in tissue conditioners had shown more superior and effective results than systemic/natural agents
Naser et al., 2022 ²³	Iraq	30	2.5% and 5% LGEO	Effect of different conc. Of LGEO on heat cure acrylic soft lining material	Hardness, peel bond strength and surface roughness	LGEO improved hardness and surface roughness of material and provided large cushioning effect and reduced damage to oral tissue
Songsan g et al., 2022 ²⁴	Switzerland	15	<i>Litsea cubeba</i> (LCEO) (10%, 30%), nystatin, CHX	Effect of different concentration of LCEO to be used as antimicrobial agent when incorporated into denture soft liners against <i>C. albicans</i> and <i>S. mutans</i>	ZOI	LCEO can be used as an effective natural product against oral pathogens
Jaiswal et al., 2023 ²⁵	India	105	<i>Lawsonia inermis</i> , <i>Withania somnifera</i> (1%, 3%, 5%, 7%)	Primary stability and loss of crestal bone	ZOI (1,7 &14 days), mean zone of antifungal efficacy	These EO showed an effective antifungal activity against <i>C. albicans</i>
Rajali et al., 2023 ²⁶	Singapore	30	OBE0, Nystatin, DH20	ZOI, MIC, MFC	to determine antifungal efficacy of OBE0 against <i>C. albicans</i>	OBE0 showed better antifungal efficacy

B. From the results of the study, it was found that addition of EO into denture soft tissue liners improved the overall antifungal property, provided large cushioning effect with reduced damage to oral tissue and had shown more superior and effective results than systemic/natural agents

CHX: chlorhexidine; DH20: deionized water; LCEO: litsea cubeba; LGEO: lemongrass essential oil; MFC: minimum fungicidal concentration; MIC: minimum inhibitory concentration; OSEO: Ocimum essential oil; ZOI: zone of inhibition

Evaluation of methodological quality

The greatest risk of bias (ROB) was observed followed by random sequence generation followed by allocation concealment. However, all the studies included in the analysis reported moderate to the lowest levels of ROB overall. Domains such as blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, selective reporting and other biases were assigned the lowest levels of ROB. Detailed assessments of ROB across various domains and individual studies are visually represented in **Figures 2 and 3**.

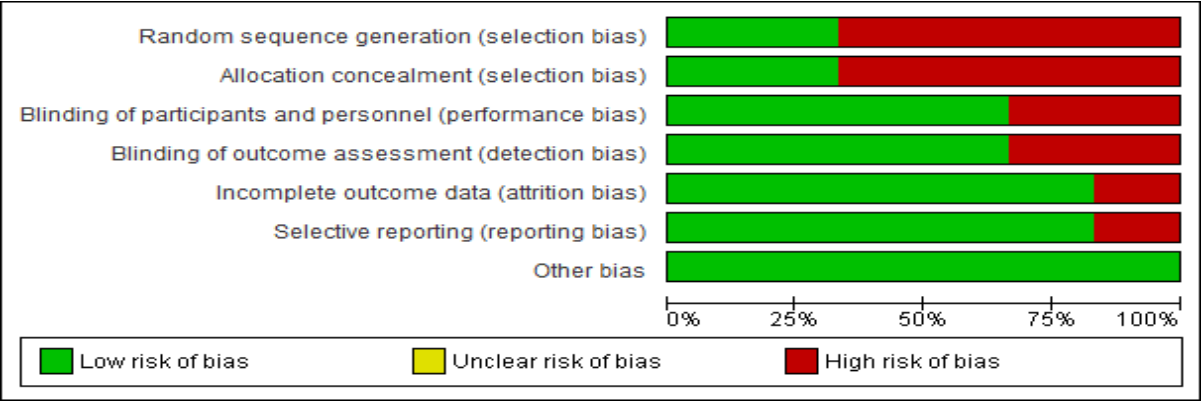


Figure 2. ROB graph: presented as percentages across all included studies.

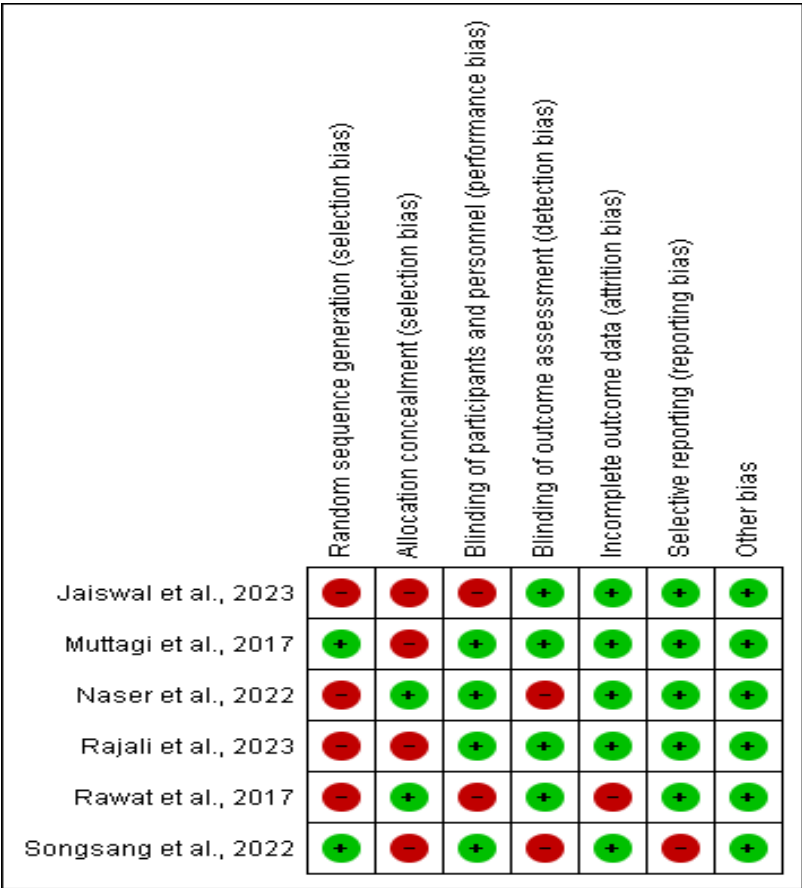


Figure 3. ROB summary: for each included study

Synthesis of results

The meta-analysis was performed to – to assess the antifungal effect of various essential oils in terms of increase in zone

of inhibition (ZOI) and decrease in surface roughness as shown in figure 4 – 9.

A) Zone of inhibition (ZOI)

Two studies^{24,26} containing data on a total of 30 sample size, of which ($n=15$) samples were placed by essential oils (OD==EOs) and ($n=15$) samples by control group for the evaluation of better efficacy between the two modalities in terms of better zone of inhibition. As shown in **Figure 4**, the SMD is 4.84 (2.14 – 7.53) and the pooled estimate signifies that ZOI on an average was 4.84 times more in EO group. ($p<0.05$).

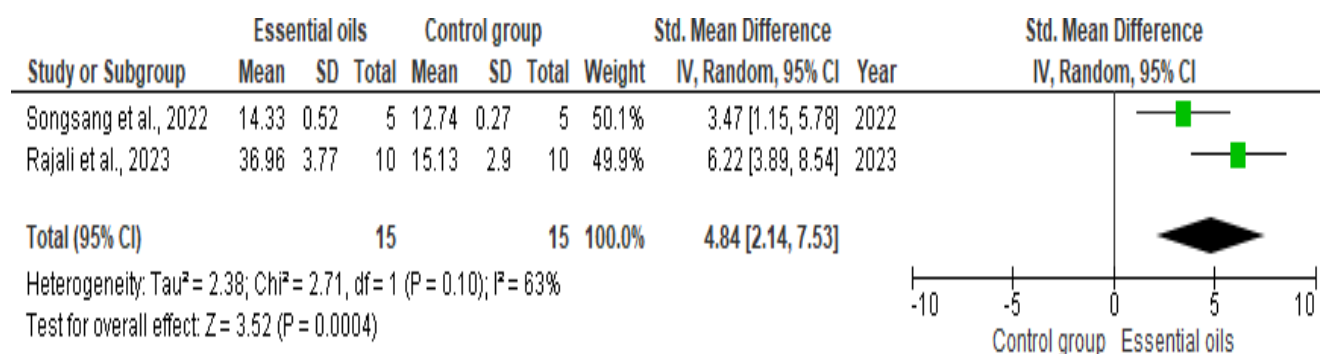


Figure 4. Comparison between EO and control group for ZOI

The funnel plot did not show significant asymmetry, indicating absence of publication bias as shown in **Figure 5**.

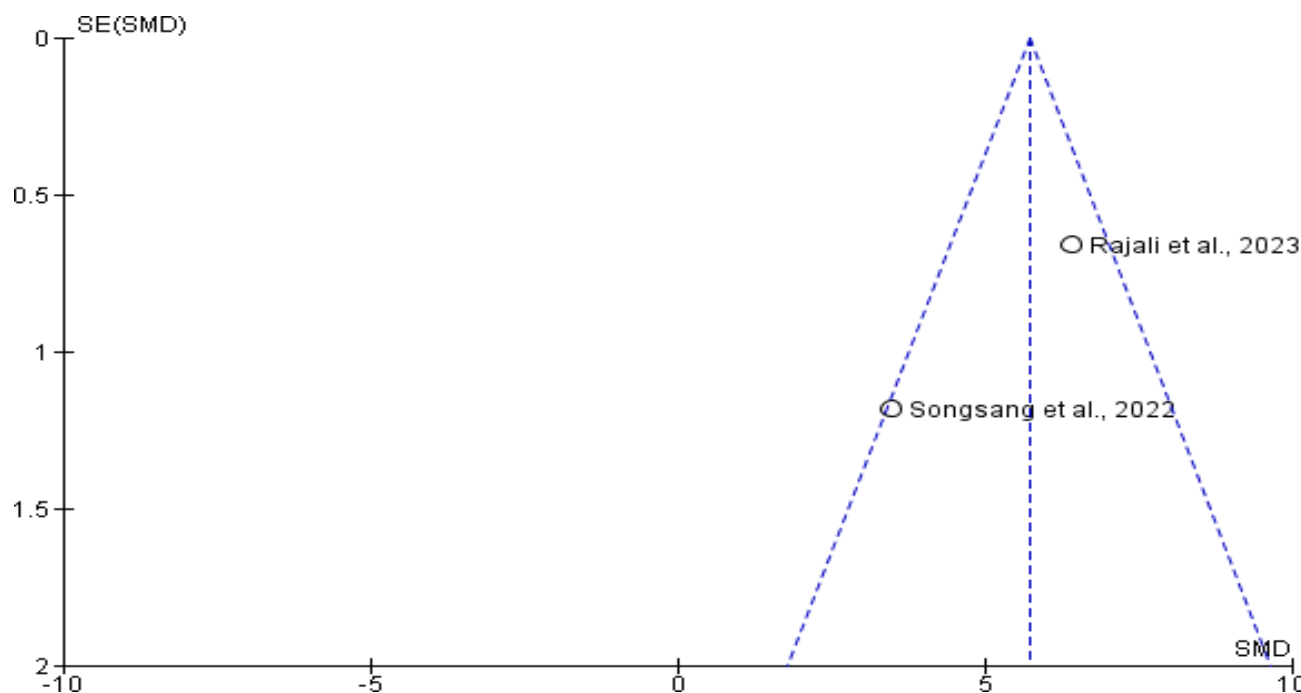


Figure 5. Begg's Funnel plot with 95% confidence intervals demonstrating an absence of publication bias.

A) Zone of Inhibition

Two studies containing data on a total of 30 sample size, of which ($n=15$) samples were placed by *Ocimum* B essential oil (OD==EOs) and ($n=15$) samples by control group (other essential oils) for the evaluation of better efficacy between the two modalities in terms of better zone of inhibition. As shown in **Figure 6**, the SMD is 14.09 (-3.76 – 31.94) and the pooled estimate signifies that ZOI on an average was 14.09 times more in EO group. ($p>0.05$).

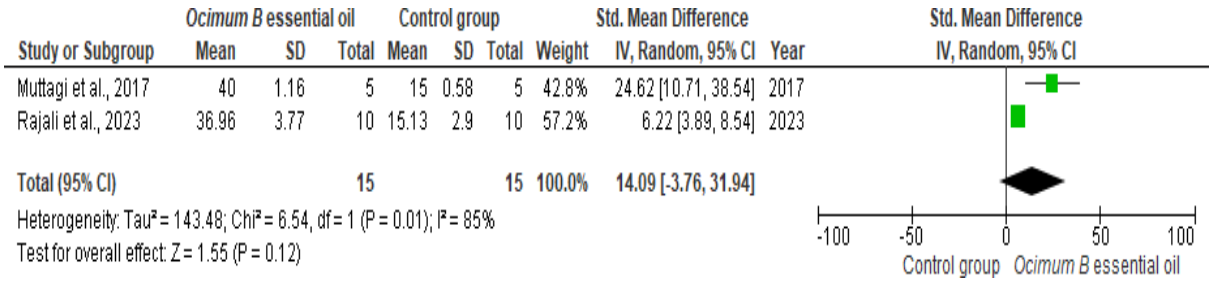


Figure 6. Comparison between *Ocimum B* EO and control group for ZOI

The funnel plot did not show significant asymmetry, indicating absence of publication bias as shown in **Figure 7**.

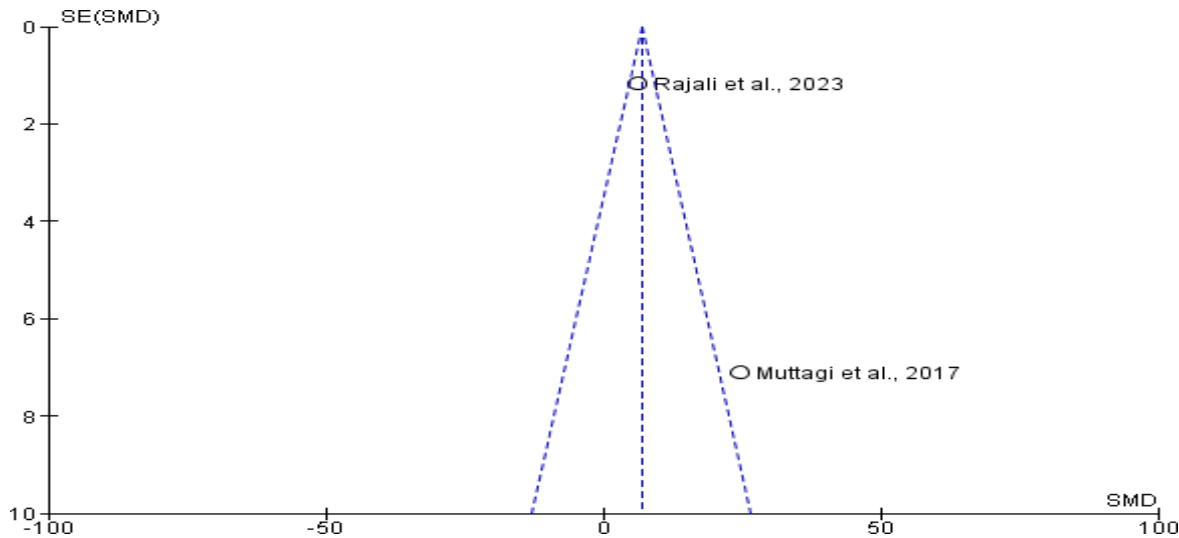


Figure 7. Begg's Funnel plot with 95% confidence intervals demonstrating an absence of publication bias.

A) Reduction in surface roughness

Two studies^{21,26} containing data on a total of 30 sample size, of which ($n=15$) samples were placed by *Ocimum B* essential oil (OD==EOs) and ($n=15$) samples by control group (other essential oils) for the evaluation of better efficacy between the two modalities in terms of better reduction in surface roughness. As shown in **Figure 8**. the SMD is -50.85 (-157.15 – 55.44) and the pooled estimate signifies that decrease in surface roughness on an average was 50.85 times more in *Ocimum B* group. ($p>0.05$).

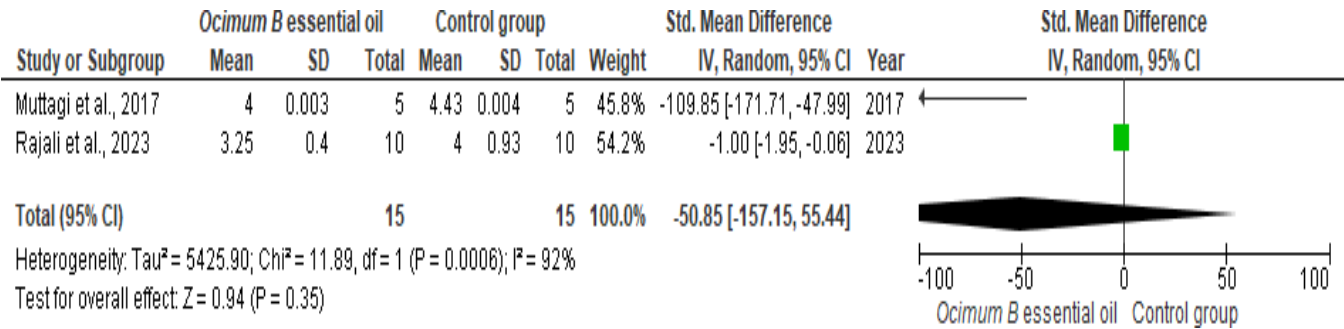


Figure 8. Comparison between *Ocimum B* EO and control group for surface roughness.
The funnel plot did not show significant asymmetry, indicating absence of publication bias.

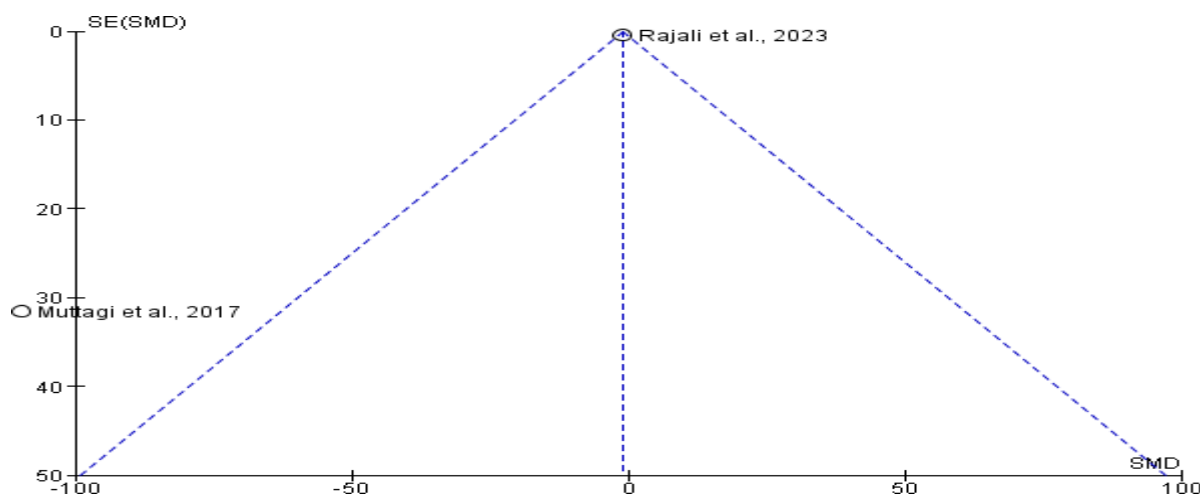


Figure 9. Showing Begg's Funnel plot with 95% confidence intervals demonstrating an absence of publication bias.

DISCUSSION

Soft denture lining materials are used to relieve abused tissue and are prone to microbial accumulation, which typically includes *Candida albicans*, *Staphylococcus aureus* and *Streptococcus mutans*.¹⁷ Antimicrobial additives have been incorporated into soft lining materials to improve the material properties and treatment efficacy but there has been an increase in antibiotic resistance and toxicity. Alternative, naturally derived additives have become incredibly common. Medicinal plant extracts (essential oils) can also act as an alternative treatment.¹⁸ The major advantages of using these natural medicinal plant extracts as antimicrobial agents includes its enhanced safety and stability without any side effects.

Iqbal et al. in their systematic review to assess the effect of incorporation of various antifungal agents into tissue conditioners for treating denture stomatitis found that included studies reported the efficacy of various, conventional antifungal medicines (nystatin, azole group and chlorhexidine etc.), silver zeolite, silver nano-particles, photocatalysts and metallic oxides), natural and herbal antimicrobials (tea tree oil, lemongrass essential oils and origanum oil) can be added in tissue conditioners. It was found that addition of antifungal agents in tissue conditioners is highly effective and can be used in the management of denture induced stomatitis (DIS).¹⁹ Similarly, according to systematic review by Ann S et al. (2021) to assess the antimicrobial effect of antimicrobial agents incorporated into denture base resins (DBRs), it was found that antimicrobial monomer or copolymer, phytochemical or phytomedicine components and other compounds resulted in reduction and prevention of growth of microorganisms.²⁰

In this systematic review, six studies²¹⁻²⁶ were

included in for qualitative synthesis and three studies^{21,24,26} for meta-analysis. Included studies reported presence of low risk of bias. The efficacy of various essential oil (EO) at various concentrations was assessed and evaluated in terms of increase in zone of inhibition (ZOI) and decrease in surface roughness against *C. albicans*. Various essential oils evaluated were *C. anthelminticum*, *Ocimum sanctum* Linn, and *Linum usitatissimum*, oregano oil and virgin coconut oil, *Litsea cubeba* essential oil (LCEO (10%, 30%), *lemon grass* essential oil (LGEO), *Lawsonia inermis*, *Withania somnifera* (1%, 3%, 5%, 7%) and *Ocimum B*. Meta-analysis showed that essential oils showed better zone of inhibition (ZOI) (SMD = 4.84 (2.14 – 7.53) and reduced surface roughness (SMD = -50.85 (-157.15 – 55.44)). From the results of the study, it was summarized that essential oils, clinically and radiographically and was superior to conventional denture soft tissue liners with better antimicrobial and antifungal efficacy. Similarly, Carvalho-Silva et al., 2024²⁷ conducted systematic review of in vitro studies to evaluate and assess the antimicrobial effect of various essential oils (EO) against biofilms formed on denture acrylic resin. Databases were searched till December 2023 yielding 12 studies. All the evaluated EO were highly effective against *Candida albicans*, *Staphylococcus aureus* and *Pseudomonas aeruginosa*. Various EO reported were *Cymbopogon citratus*, *Cinnamomum z*, *Cymbopogon nardus*, *Malaleuca alternifolia*, *Lippia sidoides* and *Salvia Officinalis*, *Zingiber officinale* and *Eucalyptus globulus*. Reduction in biofilm formation was seen.

The adherence to PRISMA guidelines, thorough literature search, and rigorous methodology, including Cochrane risk of bias assessment, underscored the credibility of these systematic reviews. With high

overall study quality and minimal bias across the included studies, the evidence base supporting therapeutic recommendations for optimizing the use of various essential oils (EO) is robust and actionable. However, there were also some limitations. A review of the evidence shows that the literature on efficacy between different essential oils incorporated into denture soft liners compared to conventional denture soft liners is sparse. Even after an unlimited search and eligibility criteria, there were very few studies with qualitative synthesis and quantitative synthesis. Only six studies were included in the final assessment. More comparative studies with larger sample size and greater follow up duration should be conducted to validate the findings of this study.

In the present review, sufficient studies with a brief observation period and a known risk of bias were included. As a result, the presently available evidence is sufficient to make therapeutic recommendations in response to the current systematic review's focus question.

CONCLUSION

It is clearly indicated from this systematic review that addition of essential oils into denture soft tissue liners improved the overall antifungal property, provided large cushioning effect with reduced damage to oral tissue and had shown more superior and effective results than systemic/natural agents. Meta-analysis showed that essential oils showed better zone of infection (ZOI) and reduced surface roughness than conventional soft liners. So, addition of essential oils in soft liner can be a successful alternative for conventional antifungal drugs overcoming shortcomings like drug resistance.

DECLARATIONS

Acknowledgement

None

Conflict of Interest

There are no conflicts of interest.

Financial support

None

This research did not receive any specific grant or financial support from funding agencies in the public, commercial, or not-for-profit sectors.

Competing Interests

The authors have no competing interests to declare.

Ethical Approval

The study was approved by the appropriate ethics committee and conducted according to relevant guidelines and regulations.

Informed Consent

Not applicable.

REFERENCES

1. Alam N, Hossain M, Mottalib MA, Sulaiman SA, Gan SH, Khalil MI. Methanolic extracts of

2. Withania somnifera leaves, fruits and roots possess antioxidant properties and antibacterial activities. BMC Complement Altern Med. 2012; 12:175.
3. Iqbal Z, Zafar MS. Role of antifungal medicaments added to tissue conditioners: A systematic review. J Prosthodont Res. 2016;60:231-9.
4. Kamal M. Pharmacological activities of Lawsonia inermis Linn: A review. Molecules. 2010;15:2139-51.
5. Webb B, Thomas C, Wilcox M, Harty D, Knox K. Candida associated denture stomatitis etiology and management: A review. Part 2. Factors influencing distribution of Candida species in the oral cavity. Aust Dent J. 1998;43:45-50
6. Graham BS, Jones DW, Burke J, Thompson JP. In vivo fungal presence and growth on two resilient denture liners. J Prosthet Dent. 1991;65:528-32.
7. Iqbal Z, Zafar MS. Role of antifungal medicaments added to tissue conditioners: A systematic review. J Prosthodont Res. 2016;60:231-9.
8. Webb B, Thomas C, Wilcox M, Harty D, Knox K. Candida associated denture stomatitis etiology and management: A review. Part 2. Factors influencing distribution of Candida species in the oral cavity. Aust Dent J. 1998;43:45-50.
9. Yiğit D. Antifungal activity of Lawsonia inermis L. (Henna) against clinical Candida isolates. Erzincan Universitesi Fen Bilimleri Enstitüsü Dergisi. 2017;10:196-202.
10. Sivakumar I, Arunachalam KS, Sajjan S, Ramaraju AV, Rao B, Kamaraj B. Incorporation of antimicrobial macromolecules in acrylic denture base resins: A research composition and update. J Prosthodont. 2014;23:284-90.
11. Emami E, Kabawat M, Rompre PH, Feine JS. Linking evidence to treatment for denture stomatitis: A meta-analysis of randomized controlled trials. J Dent. 2014;42:99-106.
12. Graham BS, Jones DW, Burke J, Thompson JP. In vivo fungal presence and growth on two resilient denture liners. J Prosthet Dent. 1991;65:528-32.
13. Skupien JA, Valentini F, Boscatto N, Pereira-Cenci T. Prevention and treatment of Candida colonization on denture liners: A systematic review. J Prosthet Dent. 2013;110:356-62.
14. Rogers TR. Antifungal drug resistance: Does it matter? Int J Infect Dis. 2002;6:47-53.
15. Corbett MS, Higgins JP, Woolacott NF. Assessing baseline imbalance in randomised trials: implications for the Cochrane risk of bias tool. Research Synthesis Methods. 2014;5(1):79-85.
16. Higgins JP, Thompson SG. Quantifying heterogeneity in a meta-analysis. Statistics in medicine. 2002;21(11):1539-58.
17. Muttagi S, Subramanya JK. Effect of incorporating seed oils on the antifungal property, surface roughness,

18. wettability, weight change, and glucose sorption of a soft liner. The Journal of prosthetic dentistry. 2017;117(1):178-85.
19. Naser HJ, Abdul-Ameer FM. Evaluating the effect of lemongrass essential oil addition on some properties of heat cure acrylic soft-lining material. Medical Journal of Babylon. 2022 Oct 1;19(4):646-52.
20. Rajali A, Zain NM, Amran NA, Azmi NH. Antifungal efficacy of Ocimum basilicum essential oil in tissue conditioner against Candida albicans: an in vitro study. Contemporary Clinical Dentistry. 2023 Apr 1;14(2):115-22.
21. Lee HL, Wang RS, Hsu YC, Chuang CC, Chan HR, Chiu HC, et al. Antifungal effect of tissue conditioners containing poly (acryloyloxyethyltrimethyl ammonium chloride)-grafted chitosan on Candida albicans growth in vitro. J Dent Sci. 2018;13:160-6.
22. Alamen BM, Abdul-Hamid Naji G. The effect of adding coconut oil on Candida albicans activity and shear bond strength of acrylic based denture soft lining material. J Res Med Dent Sci. 2019;6:310-8.
23. Sivakumar I, Arunachalam KS, Sajjan S, Ramaraju AV, Rao B, Kamaraj B. Incorporation of antimicrobial macromolecules in acrylic denture base resins: A research composition and update. J Prosthodont. 2014;23:284-90.
24. Skupien JA, Valentini F, Boscato N, Pereira-Cenci T. Prevention and treatment of Candida colonization on denture liners: A systematic review. J Prosthet Dent. 2013;110:356-62.
25. Rogers TR. Antifungal drug resistance: Does it matter? Int J Infect Dis. 2002;6:47-53.
26. Emami E, Kabawat M, Rompre PH, Feine JS. Linking evidence to treatment for denture stomatitis: A meta-analysis of randomized controlled trials. J Dent. 2014;42:99-106.
27. Graham BS, Jones DW, Burke J, Thompson JP. In vivo fungal presence and growth on two resilient denture liners. J Prosthet Dent. 1991;65:528-32.
28. Lee HL, Wang RS, Hsu YC, Chuang CC, Chan HR, Chiu HC, et al. Antifungal effect of tissue conditioners containing poly (acryloyloxyethyltrimethyl ammonium chloride)-grafted chitosan on Candida albicans growth in vitro. J Dent Sci. 2018;13:160-6.
29. Yiğit D. Antifungal activity of Lawsonia inermis L. (Henna) against clinical Candida isolates. Erzincan Universitesi Fen Bilimleri Enstitüsü Dergisi. 2017;10:196-202.
30. Webb BC, Thomas CJ, Willcox MD, Harty DW, Knox KW. Candida-associated denture e stomatitis. Aetiology and management: A review. Part 1. Factors influencing distribution of Candida species in the oral cavity. Aust Dent J. 1998;43:45-50.
31. Goiato MC, Zuccolotti BC, Moreno A, Vechiato Filho AJ, Paulini MB, Santos DM. Effect of nanoscale particles incorporation on microhardness of polymers for oral prosthesis. Contemp Clin Dent. 2016;7:307-11.
32. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, Shamseer L, Tetzlaff JM, Akl EA, Brennan SE, Chou R. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. bmj. 2021;29;372-381.