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Recent progress in materials development of denture tissue conditioner-A systematic review

Bakhtawar Mobeen[1], Muhammad Amer Khan[2], Humaira Jabeen[3], Saad Liaqat[4]

[1]Department of Dental Materials, Institute of Basic Medical Sciences, Khyber Medical University, Peshawar, KPK, Pakistan
[2]Department of Dental Materials, Institute of Basic Medical Sciences, Khyber Medical University, Peshawar, KPK, Pakistan
[3]Department of Dental Materials, Institute of Basic Medical Sciences, Khyber Medical University, Peshawar, KPK, Pakistan
[4]Department of Dental Materials, Institute of Basic Medical Sciences, Khyber Medical University, Peshawar, KPK, Pakistan

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Corresponding Author:
Saad Liaqat
saad_kcd@yahoo.com

ABSTRACT

Denture tissue conditioners play essential role in treating damaged oral mucosa, improving the comfort of patients, and providing effective adaptation of prostheses. Innovations in materials science over the past few decades have produced better formulations that have improved mechanical, antibacterial, and physical properties. This systematic review aims to assess and summarize the most recent data on improvements in denture tissue conditioners, emphasizing on material improvements, clinical performance, and antimicrobial efficiency. A complete literature search was undertaken using electronic databases such as PubMed, science direct, Cochrane and Medline, with publications published between 2011 and 2025. Predetermined exclusion and inclusion criteria were used to select papers, with a focus on randomized controlled trials, in vitro, and in vivo studies on newer experimental tissue conditioner materials. Data has been gathered and evaluated for bias. In total, 41 studies fulfilled the inclusion criteria. Major advances include the addition of antibacterial agents (such as silver nanoparticles, essential oils and fluorescent carbon), improved mechanical properties and increased conditioner longevity. Numerous studies found considerable reductions in microbial colonization while maintaining integrity of material. Modifications made with organic compounds and biocompatible resins have also showed promise in terms of mucosal healing and clinical results. The clinical performance and therapeutic capacity of denture tissue conditioners have been significantly improved by recent advances. Yet, to confirm these results and encourage broad clinical adoption, further extensive long-term clinical investigations are required. Future studies should concentrate on maximizing the harmony of antibacterial efficacy, patient comfort, and material performance.

Introduction

Missing teeth can be replaced either through removable or fixed prosthesis. Bridges and implants are examples of fixed prosthesis, whereas dentures are examples of removable prosthesis. With aging of population, removable dentures (partial and complete denture) have become more commonly used in prosthetic dentistry as substitute for missing teeth[1].Denture helps with regaining function, such as chewing and speaking, and also maintaining patient's physical appearance and overall health[2]. In warm, humid and carbohydrate rich mouth, denture bases having rough surfaces are prone to colonization and penetration by microorganisms, particularly candida albicans, which is known as primary cause of denture stomatitis[1].

Denture stomatitis affects 15 to 65% of healthy denture users. Denture stomatitis is caused by a variety of factors, including trauma to tissue from ill-fitting dentures, a lack of denture hygiene or improper denture hygiene, dietary habits, consistent denture use without removal, long term illness, and an immunocompromised and weakened immune system. Denture wearing practices, xerostomia, medications, and nutritional factors are all risk factors[3].

Management of denture colonized by candida and poor adjustment to the oral tissue, there are mainly two treatment options: either build a new denture or reline an existing denture to treat denture stomatitis and improve fit. This eliminates the need for new denture. Some practitioners consider it more cost-effective and time saving[4]. So therefore prior to discarding ill-fitted dentures and fabricating new ones, a short-term soft liner is recommended to adjust the alveolar ridges and oral mucosa in preparation for poly (methyl methacrylate) denture's base[1]. Liners are less invasive and less expensive than making a new denture .

Relining is the process of adding new material to a denture to fill the gap between the primary denture contour and the affected tissue contour. Denture relining is recommended when complete dentures are unfit and have poor stability and retention[5].

Proper maintenance of denture lining materials is necessary to avoid the growth of microoragansisms. Removable dental prostheses are frequently relined with the resilient material. Soft liner is type of resilient materials introduced to denture occlusal surface, that sits on stress-absorbing oral mucosa. Between contacting surfaces of the oral mucosa and denture base, these materials create a well-supported and cushioned layer[8]. They can be processed in in a dentist's office (self-cured) for their immediate use and/or in dental laboratories (heat cured)

Based on composition resilient liners are classified, as acrylic or silicone. Based on durability, they can also be classified as long-term liners and short-term liners. Tissue conditioners are short-term flexible liners made of polymers that are amorphous, which are a powder polymer and a plasticizer liquid mixture. Resilient liners, used to protect supporting structures and prevent discomfort and persistent soreness from dentures. Resilient liners are known to benefit patients who wear dentures and have ridge atrophy, non-resilient and thin mucosa, and bony undercuts.

Tissue conditioners are commonly used prior to denture replacement to improve function and fit of an ill-fitting denture[15]. They are resilient, temporary soft liners, used to address a variety of problems of patients and some clinical applications[16]. Tissue conditioners, provide temporary (for 24-36 hours) cushioning effect that prevents mastication loads from being transferred to underlying tissues. As a result, they are used to treat traumatized soft tissues, wounds caused by use of an ill-fitting denture, and surgical wounds following extraction of tooth[6].Tissue conditioners help to heal damaged mucosa while still supporting a denture and creating dynamic impressions[17].

Tissue conditioners are also used for relining of immediate dentures, as well as decreasing and uniformly delivering stresses on basal seat mucosa [16]. They are broadly used to distribute stress more uniformly on supporting tissues, particularly traumatic tissues, in order to reduce hard masticatory forces. As a result, it has been used for a variety of intraoral clinical purposes, like treatment of tissue, temporary obturator, stabilization of base plate, surgical splint liners, and functional impression material [18]. Tissue conditioner viscoelastic properties enable them to serve as both tissue conditioners and functional impression materials. Tissue conditioners most important property is that it is biocompatbile, non-irritant because of absence of acrylic monomers from liquid component[19]. It is essential to remember that tissue conditioners are easily degradable and prone to microorganism colonisation in clinical settings., therefore should be replaced with fresh material after 2-3 days.

Candida albicans, have been observed to invade and occupy on degraded surfaces of tissue conditioners, often causing denture stomatitis or infections, which can cause systemic disorders like aspiration pneumonia in immune compromised individuals. However they do, have some other drawbacks, such as the presence of porosity and surface flaws, a residual taste after use, capacity of water up taking, poor adhesion to acrylic resin, a predisposition to color change, difficult to clean, and premature hardening due to solubility of plasticizer.

Daily brushing and cleaning of dentures is required for deep cleaning. The surface of tissue conditioner, retains more plaque than the PMMA resin due to its high porosity and viscosity. Furthermore, the surface of tissue conditioner is sensitive to brushing. As a result, mechanical cleaning is not suggested. These factors make it challenging to maintain the tissue conditioner surface clean. Excessive saliva flow and a lack of patient compliance may jeopardize the effect of topical drug application in oral cavity. Systemic route of administration requires high drug doses with a high chance of side effects. To address this issue, antifungal medications like azoles, polyenes, antiseptics and antibiotics have been recommended to incorporate in tissue conditioner. In this strategy the addition of drugs into the tissue conditioner can result in a lower cost, concurrent management of the infection and injured mucosa, and is a more convenient method because of fewer procedural steps.

Second most common problem associated with tissue conditioners is lack of adhesion. Problems of solubility and water sorption, which are due to growth of Candida and stresses at interface of denture base and liner resulting in de bonding. Soft denture liners (tissue conditioners) viscoelastic properties are essential because they designate the material's ability to cushion tissues and maintain its shape during mastication. Denture liners temporary nature is due to the leaching of the plasticizer and alcohol, as well as the adsorption of saliva and water, which results in the loss of viscoelasticity and thus compliance. Successful relining depends upon bond strength between lining material and resin base. De bonding occurs as a result of an inadequate bond to denture or low cohesive strength, and reduces procedure's durability[3]. Bond strength depends on both reline materials chemical composition and denture base polymers composition. A weak bond has been linked to decreased mechanical strength of relined dentures, accumulation of bacteria, and discoloration. Higher bond strengths can be achieved when reline materials are chemically similar to the denture base.

Another problem with TC is that it undergoes surface degradation with time and shows surface roughness and porosity. It is claimed that the porous structure of these lining materials creates an ideal environment for fungus growth. Tissue conditioner hardens due to the vaporization of alcohol and plasticizer and must be replaced. Ethyl alcohol evaporates quickly, with considerable quantities lost in the first 12 hours and a maximum level reached within 60 hours

METHODOLOGY

The most recent preferred Reporting Items for systematic reviews and meta-Analysis guidelines of PRISMA for reporting were followed in this systematic review[24].

Focus Question

The focus query formulated for this investigation was

"What is the effect of various additives on antifungal, antibacterial and mechanical properties of different tissue conditioners"

The research question was developed using PICOS format.

(P) Problem: Patients suffering from stomatitis caused by dentures

(I) Intervention: Tissue conditioner incorporated with various additives.

(C)Comparison: Tissue conditioners without additives.

(O)Outcomes: Antibacterial activity, antifungal activity, reduction of fungal growth and decrease of fungal colonies, and significant modifications to the mechanical and physical properties of TC.

Study designs (S): In-vitro studies, animal studies, and clinical studies.

Literature Search

A literature search was conducted using various electronic databases such as PubMed, Cochrane Library, Medline and Science direct from 2011 up to 2025 by using different mesh term or key words as shown in figure 1.

Eligibility Criteria

Inclusion criteria:

1. Open access articles

2. Appropriately referenced database

3. Original research and clinical studies

4. Articles from the last 15 years

Exclusion criteria:

1.Articles that are published in languages other than English

2.Case reports
3.Articles without access to the complete text

4.Unpublished data, letter to the editor
5.Articles having incomplete data

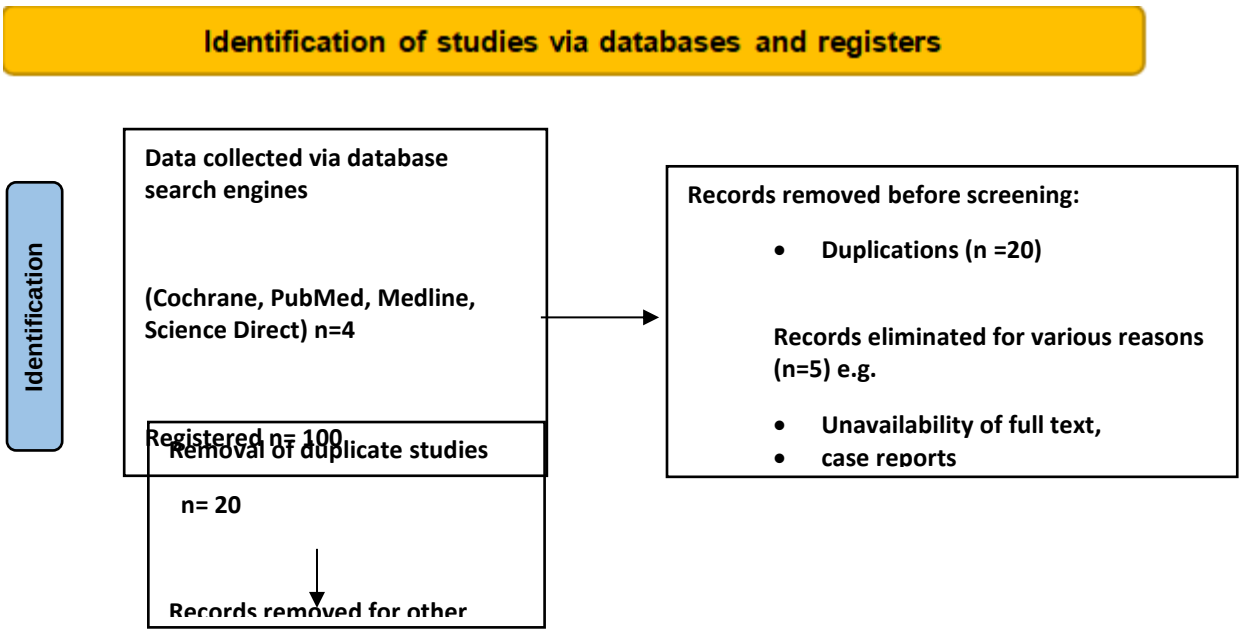
The entire texts, abstracts, and titles of the eligible papers were compared to the inclusion and exclusion criteria by two independent reviewers. Any disputes were discussed and resolved by agreement

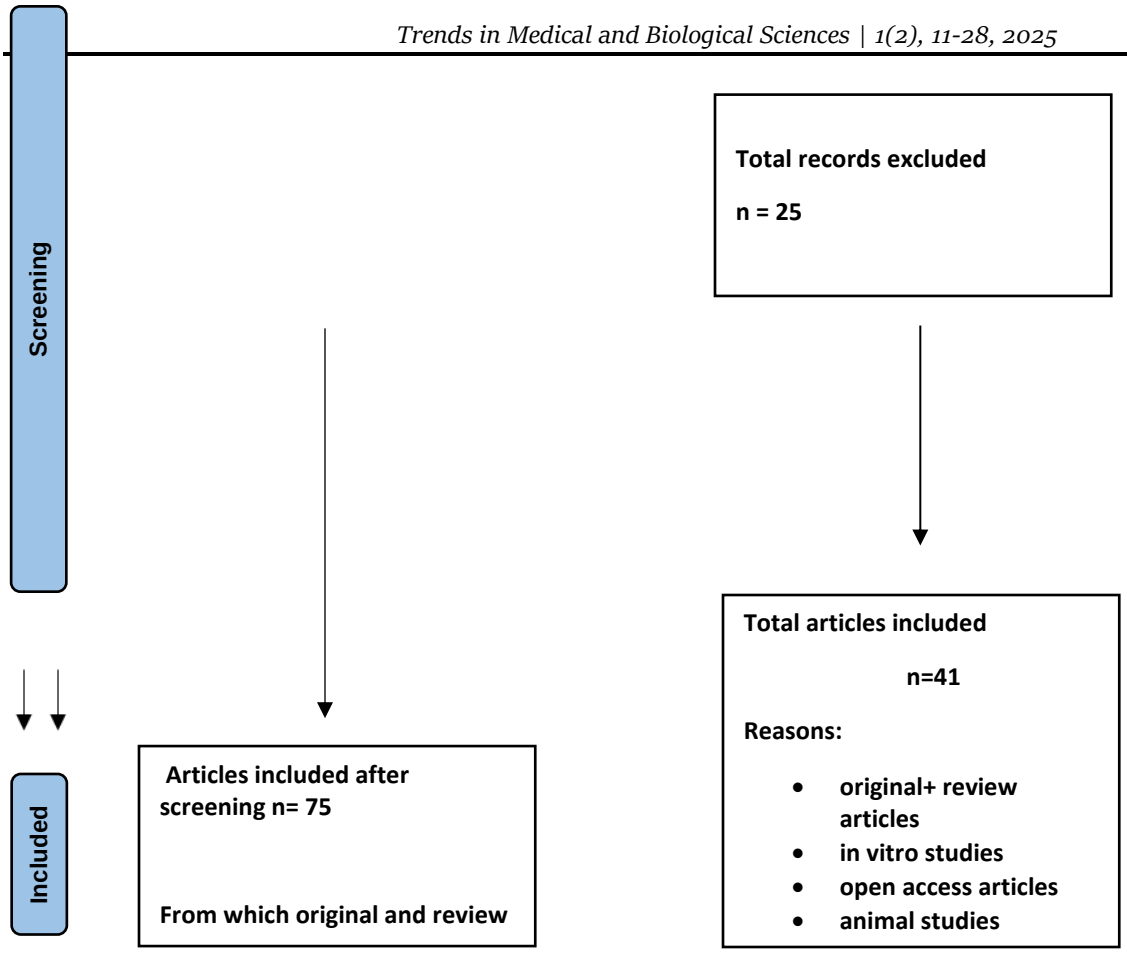
RESULTS:

A total of 100 articles were found by the initial title searched. Twenty articles were eliminated after duplication, bringing the total down to 80.

Out of eighty, 39 publications were eliminated after additional investigation for other reasons, including inadequate data, case reports and the lack of full text. Thus, 41 articles were the final count after deductions as illustrated in Figure 1.

Figure 1: Prisma flow chart of recent progress in materials development of denture tissue conditioner – A Systematic Review.





This systematic review is based mainly on original studies and some review articles, reaching 41 articles in total as shown in Figure 3.

Table 1 displays an evidence-based table focusing on the various publications included in this systematic review. Different studies highlighted the different additives in tissue conditioner like biocompatible polymers, nanoparticles and natural additives (essential oils, herbs) and their effect on its mechanical and biological properties as shown in Table 1.

Year of Publication	Author	Type of Study	Sample Size	Objective	Conclusion	Limitations/ Recommendations
2025	Mohika et al[25]	In vitro	4 groups	Create a chitosan-mediated fenugreek nanocomposite and determine its antifungal effectiveness on denture bases relined with tissue conditioner combined with the nanocomposite	Study showed a viable strategy for inhibiting candidal growth, which could enhance denture wearers' oral health outcomes	Artificial saliva may not accurately mimic oral physiological parameters when used in place of real saliva
2025	Vrinda et al[26]	In vitro	4 groups	Evaluate the antimicrobial effects of K18 quaternary ammonium methacryloxy silane added to tissue conditioner	Without affecting hardness, flow, K18-MMA gave tissue conditioners strong antibacterial qualities against S.sangius, S. mutans and C. albicans	Long-term antibacterial and biocompatibility qualities must be identified and clinical efficacy in clinical studies is necessary
2025	Ariyani et al[27]	In vitro	3 groups	Evaluate the antifungal properties of origanum vulgare gel-containing denture liner against Candida albicans	Addition of origanum vulgare Gel to denture liner at a concentration of 6.25% inhibited candida albicans growth	Future studies should be conducted to identify potential modifications to denture liners physical properties
2025	Patrycja et al[28]	In vitro	4 groups	Impact on a temporary soft liner's biological and physicochemical properties of adding a novel monomer containing a quaternary ammonium group	Showed acceptable microbial, physico-mechanical and immunological properties and also showed reduction in growth of c. albicans	Future studies should be conducted to identify potential modifications to tissue conditioners physical properties
2025	Mostafa A et al[4]	In vitro	24 samples	To evaluate the antimicrobial activity of TC loaded with extract powders of propolis, pumpkin and	Propolis extract powder added to TC at 5% and 10% shown strong	The precise mechanism of action and pharmacokinetics of these naturally occurring

				rosemary against s.mutans and c.albicans	antibacterial activity against S. mutans and candida albicans	antimicrobial drugs still need to be studied
2024	Saeed Nikanjam et al[29]	In vitro	126 samples	Evaluation of antifungal and antibacterial properties of tissue conditioner loaded with nanoparticles of copper oxide	The tissue conditioners with copper oxide nanoparticles shown antibacterial activity against P. aeruginosa, E. faecalis and candida albicans	further research should be conducted, to determine the ideal concentration of CuO nanoparticles in TC
2024	Carolina et al[30]	In vivo	3 groups of rats	Evaluate tissue response of denture stomatitis in a rat model treated with β-cyclodextrin complexed with antifungal added to tissue conditioner	Combination of antifungal with TC resulted in the palatal mucosa's tissue healing, the suggested treatment may be promising for denture stomatitis	This study's drawback is that, because of the possibility of contamination in the SDA, it could not be carried out for longer than 14 days
2024	Sina Safari et al[31]	In vitro	4 groups	Evaluate tissue conditioner's antimicrobial property modified with silver nanoparticles and chitosan	Combination showed antimicrobial activity and can be used as promising alternative for denture stomatitis	Additional biological evaluation should be conducted
2024	Pushkar et al[32]	In vitro	64 samples	To assess the tensile strength of GC soft liners and visco-gel at various time intervals with and without 10% w/w cocos nucifera oil	The addition of 10% w/w cocos nucifera oil improved the tensile strength of GC liners and visco-gel from day 1 to 14	Additional research is required to validate the conclusions of this study, as the findings cannot be immediately applied to clinical settings
2023	Ghada et al[33]	In vitro	5 groups	Evaluate the anti-fungal activity of origanum oil, garlic oil, black seeds oil and	Incorporation of origanum oil and garlic oil to tissue conditioner inhibited C.	The tissue conditioner comprising ginger oil and black seed oil did not inhibit yeast growth

				ginger oil added to tissue conditioner against candida albicans	albicans development	
2022	Asfia et al[34]	In vitro	15 samples	Evaluate the physio mechanical properties of tissue conditioner enhanced with created chitosan oligosaccharide	Adding chitosan oligosaccharide to TC at various concentrations increases the material's hardness, sorption, and solubility	In vitro binding strength to denture base materials and material surface roughness should be conducted
2021	Worapor n et al[35]	In vitro	20 samples	Evaluate the physical, antifungal and mechanical properties of tissue conditioner loaded with various concentrations of zinc oxide nanoparticles	15% ZnOnps added to TC showed an antifungal activity without any adverse effects on tensile bond strength and the penetration depth of tissue conditioner	In-vivo studies are recommended for accurate findings
2021	Ayse et al[36]	In vitro	50 samples	To assess how adding fluorescent carbon nanoparticles affects ti ssue conditioner's hardness, tear resistance, and tensile bond strength	Adding FCN to acrylic-based TCs had no negative impact on their mechanical qualities	To assure clinical success, various mechanical qualities, such as surface roughness and water absorption, should be examined
2021	Jie Deng et al[1]	In vitro	4 specimen s	To evaluate the antifungal efficacy of soft liner containing silver nanoparticles	In situ-synthesized AgNPs in the acrylic soft liner effectively controlled candida albicans	AgNPs release may disrupt the soft liner's microstructure, which would facilitate the growth of candida albicans.
2018	Kim et al[6]	In vitro	4 samples	Evaluate antifungal efficacy and tensile strength of tissue conditioner incorporating with nystatin loaded alginate particles	Even at lower nystatin concentrations, the tissue conditioner's nystatin-alginate microparticles demonstrated potent antifungal activity	Research should be done on alternative tissue conditioner brands that use the same amounts of antimicrobial agent

2019	Maike Herla et al[11]	In vitro	40 samples	Evaluate the mechanical and surface characteristics of chitosan salt-modified resilient liners	Addition of CS salts has no clinically significant effect on the mechanical qualities of modified resilient liners	Other material qualities, such as water solubility, sorption, and antifungal testing, should be conducted to further examine the properties of CS salts added to resilient liners
2015	Koteswara et al[37]	In vitro	60 samples	Evaluation of soft liners modified with tea tree oil for antifungal properties	Adding tea tree oil to soft liners reduces c.albicans growth, indicating a successful antifungal treatment for denture stomatitis	Future studies should be conducted to identify potential modifications to tissue conditioners' physical properties
2013	Akanksha et al[15]	In vitro	2 groups	Evaluate the antifungal, surface roughness, tensile strength and bond strength of a tissue conditioner containing origanum oil	Adding origanum oil to tissue conditioner can lessen candida albicans adhesion without affecting the bond strength to acrylic	More research is needed to assess the effectiveness of origanum oil with various tissue conditioners and determine its possible clinical application
2017	Pragati et al[16]	In vitro	5 groups	Evaluate anti-fungal and mechanical properties of tissue conditioner loaded with fluconazole, oregano oil and virgin coconut oil	Incorporating natural compounds into tissue conditioner can be utilized as an effective alternative to topical or systemic synth etic antifungal drugs	Study was conducted under supervised laboratory conditions; consequently, in-vivo studies are recommended for accurate findings
2017	Kavita et al[38]	In vitro	3 groups	Evaluation of mechanical and physical properties of tissue conditioner incorporated with limidazolium chloride	Results showed that modified TC considerably inhibited fungus development, both in material suspension and on surface	Dynamic viscoelastic property of material should be investigated further. composition of IL-incorporated TC should be modified to minimize cytotoxicity
2017	Yoshihito et al[17]	In vitro	4 groups	To assess the fluidity, hardness and antifungal activity of a	Tissue conditioner containing juncus	Effect of juncus powder on other desirable properties of

				tissue conditioner loaded with Juncus powder	powder had a strong growth inhibitory impact on c. albican. Furthermore, both mechanical qualities were found to be within the ISO-specified ranges	tissue conditioner should be investigated
2014	Pokpong et al[18]	In vitro	2 groups	Evaluate the antifungal afficacy of TC with lemongrass against candida albicans	Tissue conditioner mixed with lemongrass essential oil showed anti-candida activity, reduces t he risk of candidal infection	Future research must examine the impact of adding lemongrass, on the desired qualities of tissue conditioners
2020	Tsubasa Naoe et al[19]	In vitro and In vivo	2 groups	Evaluate the mechanical and antimicrobial properties of tissue conditioner loaded with cetylpyridinium chloride with montmorillonite	Tssue conditioner containing CPC-Mont has antibacterial characteristics and comparable mechanical qualities as tissue conditioners now on the market	The half-life of the antimicrobial agents once they are combined with tissue conditioners and the pace at which they are released from it should be investigate
2022	Hina et al[20]	In vitro	4 groups	To evaluate tissue conditioner formulations using chitosan nanoparticles and essential oils for their antifungal capability, hardness and kinetics	TCs with essential oil-loaded CSNPs appear to be a promising new treatment for denture stomatitis	Additional biological evaluation should be conducted
2018	Kensuke et al[21]	In vitro	4 groups	Assessment of the impact on candida albicans adhesion of adding surface pre-reacted glass ionomer filler to tissue conditioner	TC with 10 wt% or more S-PRG filler may lessen the adherence of candida albicans to the TC surface	The amount of filler was limited due of its impact on surface and mechanical characteristics
2021	Maryam et al[22]	In vitro	4 groups	Evaluate the physical and biological	Tissue conditioner	To carry out research on additional tissue

				properties of TC loaded with carum copticum L	loaded with essential oil from carum copticum L. had sufficient physical, biological, and release characteristics to be used as treatment for denture stomatitis	conditioner brands that contain the same amounts of carum copticum L
2017	Dikshita et al[39]	In vitro	5 groups	Evaluate the effectiveness of leaf extract of neem combined with nystatin, ketoconazole and chlorhexidine diacetate in a tissue conditioner against Streptococcus mutans and candida albicans	Neem leaf extract showed great promise as a strong antibacterial agent against Streptococcus mutans and candida albicans	Study is limited to only one tissue conditioner brand. Therefore, the outcomes of this study might not apply to other tissue conditioners that contain the same amounts of ingredients
2018	Hsin-Lin et al[40]	In vitro	4 groups	Evaluate antifungal effect on growth of candida albicans of tissue conditioners loaded with poly acryloyloxyethyltrimethyl ammonium chloride grafted chitosan	Modified tissue conditioners with CS or QCS resulted in much fewer fungus colonies	Additional physical properties of modified tissue conditioner should be evaluated

Integrating nanocomposites of chitosan-mediated fenugreek into tissue conditioners is a promising way to reduce fungal growth, which could improve denture wearers' oral health outcomes[25]. K18 quaternary ammonium methacryloxy significantly add antibacterial qualities to tissue conditioner against s. mutans and c. albicans[26]. Addition of origanum vulgare Gel to tissue conditioner successfully prevents candida albicans growth[27]. Copper oxide nanoparticle-containing tissue conditioners shown satisfactory antibacterial activity against candida albicans and P. aeruginosa[29]. Addition of cocos nucifera oil showed increased in tensile strength of *tissue conditioner*[32]. *Addition of surface pre-reacted glass* ionomer filler may decrease c. albicans adhesion of candida albicans on surface of TC[21]. When treating denture stomatitis, neem leaf extract can be added to tissue conditioners as the preferred treatment[39]. Tissue conditioner that contains Juncus powder significantly inhibits the growth of candida albicans[17]. Tissue conditioner mixed with lemongrass essential oil exhibited anti-candida activity, which reduces the risk of candida infection[18]. Quaternized chitosan is proved to be novel and safe antifungal drug for tissue conditioning for clinical use[40]. The use of oregano oil and virgin coconut oil in tissue conditioners can be a successful substitute to topical or systemic antifungal medications[16].

Adding origanum oil to tissue conditioner may reduce candida albicans' adhesion without altering its bond strength to acrylic resin[15]. Tissue conditioner loaded with essential oil from carum copticum L. had sufficient biological and physical properties to be used as a novel treatment for stomatitis of dentures[22]. Recently created TC containing cetylpyridinium chloride

montmorillonite had superior antibacterial qualities and having the same mechanical characteristics and biocompatibility as conventional tissue conditioners[19]. Using tissue conditioner with ionic solutions dramatically reduced the fungus growth[38]. Propolis extract powder added to TC at 5% and 10% shown strong antibacterial activity against s. mutans and candida albicans[4].

Tissue conditioner modified by chitosan and created chitosan oligosaccharide in an antifungal concentration exhibited increased hardness, solubility and sorption[34]. The incorporation of fluorescent carbon nanoparticles, which are known for its antibacterial and antioxidant capabilities, into acrylic-based TC showed no negative impact on mechanical qualities[36].

DISCUSSIONS:

Enhancement of antibacterial activities:

The antimicrobial and antibiofilm characteristics of denture liners are essential for clinical use. Some studies tried to improve liners' antibacterial capabilities without compromising their mechanical qualities[36]. The use of antimicrobial compounds in tissue conditioners has sparked interest in controlling microorganisms[39]. Nanoparticles exhibit antibacterial qualities. Tissue conditioner samples with various concentrations of copper oxide nanoparticles when incubated in the growth culture media containing P. aeruginosa and E. faecalis, showed that the growth of the culture media varied considerably across different copper oxide nanoparticle concentrations, indicating that bacterial growth decreased with increasing concentration of nanoparticle[29]. 15% neem leaf extract showed potential antimicrobial activity against streptococcus mutans and candida albicans. In case of denture stomatitis, neem leaf extract, which is widely available and inexpensive may be used as the preferred treatment by incorporating it into tissue conditioners[39]. According to a study, C. copticum L.'s essential oil possesses strong antibacterial properties. These findings imply that TC loaded with C. copticum L. essential oil may be a good option for treating denture stomatitis and damaged mucosa at the same time. However, C. copticum L. can also be employed to produce new antimicrobial compounds to manage microbial infections and associated biofilm formation, which is important for the growing issue of microbial resistance to antimicrobial treatments[22]. In recent study, a new tissue conditioner containing cetylpyridinium chloride montmorillonite was shown to have superior antibacterial activity, comparable mechanical characteristics, and biocompatibility to materials that are sold commercially[19]. TC having CPC may be crucial in reducing aspiration pneumonia in elderly patients because of its superior antibacterial properties, biocompatibility, and mechanical qualities[19]. Propolis extract powder added to TC at 5% and 10% shown strong antibacterial activity against S. mutans and candida albicans. Natural antibacterial compounds can be incorporated into TC as a useful substitute for topical synthetic treatments[4].

Imparting of antifungal activities:

Several studies were conducted to improve the antifungal activity of tissue conditioner by adding various materials. Ionic liquids contain antifungal properties and have been utilized as plasticizers[38]. In recent study to increase the antifungal action of tissue conditioner, 1-Decyl-3-methy-limidazolium chloride, an ionic liquid, was used. The study's findings showed that, with regard of material compliance, ionic liquid incorporated TC satisfied the requirements needed[38].Fenugreek extracts, have shown efficacy against candida albicans and aspergillus niger[25]. As a result, green nanoparticle manufacturing as a natural and environmentally benign strategy is critical for improving antifungal activity against candida albicans, a cause of denture stomatitis. This study found that combining chitosan with fenugreek as a nanomaterial could act as a natural antifungal agent, potentially preventing candidal infections while maintaining oral mucosa health and denture structure durability[25]. Significant antibacterial and antifungal activity against s. mutans and c. albicans was demonstrated by K18-containing groups[26]. fungal hyphae of plaque biofilm and the biofilm that came into contact with the acrylic surface were both inhibited by the K18 QAS MMA addition in tissue conditioner[26]. Significant antifungal action against candida albicans has been demonstrated by origanum vulgare[27]. It has been suggested to add origanum vulgare gel to tissue conditioner at a concentration of 6.25% since it successfully stops candida albicans growth over 14 days[27]. Visco-gel and GC soft liner's tensile strength increased from day 1 to day 14 following immersion in distilled water when 10% w/w cocos nucifera oil was added[32].

Kensuke et al, discovered that tissue conditioner containing 10% wt or more surface pre reacted glass ionomer filler decrease adhesion of c. albicans to the tissue conditioner surface. While the influence of content of filler on mechanical and surface properties limited the filler content. In practice 10% wt may be workable for tissue conditioning of denture-bearing mucosa[21]. Yoshihito et al. conducted a study and discovered that a tissue conditioner containing juncus powder had an inhibitory effect on candida albicans. It has been recommended that using a juncus-combined to tissue conditioner may help denture wearers avoid denture stomatitis and oral candidiasis[17]. PoKPong et al discovered that coe-comfort tissue conditioner reinforced with essential oil of lemongrass proved satisfying in vitro anti-candida efficacy comparable to that of nystatin[18]. Study showed that tissue conditioners modified with chitosan or quaternized chitosan, decreased number of fungal colonies. However chitosan and quaternized chitosan had no effect on tensile bond strength between modified tissue conditioners and control[40]. Because oregano oil and virgin coconut oil are natural products, having additional benefit of being safe and inexpensive, they can be utilized as an alternative to the synthetic antifungal agents now in use[16]. In regards of physical and mechanical properties TC loaded with oregano oil showed superior properties among all tested groups[16]. The tissue conditioner gained a strong antifungal effect from origanum oil. Origanum oil-containing tissue conditioners demonstrated improved candida albican resistance without decreasing bond strength to the heat-polymerized acrylic resin denture[15].

Effects of additives on mechanical properties:

Antimicrobial compounds often affect material solubility and sorption, which can have an impact on the stress distribution properties and dimensional stability of tissue conditioners[34].

Successful relining depends upon bond strength between lining material and resin base. De bonding occurs as a result of an inadequate bond to denture or low cohesive strength, and reduces procedure's durability. Stronger adhesion is obtained when chemical properties of the materials are similar. Surface treatments improve adhesion to the prosthesis base. The material's durability is compromised by changes in hardness and rough surfaces[3]. According to Ahmad et al. Liner adhesion to base polymers is affected by chemical composition of the materials involved, as well as resin type, surface treatment and thermal cycle[3]. The incorporation of chitosan and chitosan oligosaccharide to tissue conditioners in various ratios enhances the material's hardness, solubility and sorption. fortunately, these modifications are not significant enough to interfere with their tissue healing ability[34]. Modified silicone lining materials with hydrophobic surface treated silica filler (filler loading of 6,8 and 10 phr) have superior mechanical properties as compared to two commercial silicone soft lining materials. Ultimate tensile strength, elongation percentage, tear strength, and shore A hardness of experimental lining materials enhanced in direct proportion to the amount of silica filler used (from 6 to 10 phr)[41]. Incorporation of 10% w/w cocos nucifera oil statistically increases the tensile strength of visco-gel and GC soft liner, from day 1 to day 14, after immersion in distilled water[32]. The mechanical properties of acrylic-based tissue conditioner were unaffected by the addition of fluorescent carbon nanoparticles which are well-known for their antibacterial and antioxidant qualities. However, the addition of FCN to a silicone-based soft denture liner resulted in

Author and publication year	Type of study	Study duration	Was the characterization of incorporated material performed	Was the biocompatibility of incorporated material assessed	Was the antifungal property assessed	Was the anti-bacterial property assessed	Were the tensile bond strength and tear resistance assessed	Was the shore A hardness assessed	Total score
Mohika et al[25], 2025	In vitro	14 days	Yes	No	Yes	No	No	No	33.33%
Vrinda Gupt et al[26], 2025	In vitro	4 weeks	No	Yes	Yes	Yes	No	Yes	50.00%
Ariyani et al[27], 2025	In vitro	14 days	No	No	Yes	Yes	No	No	33.33%
Patrycja et al[28], 2025	In vitro	2 days	No	Yes	Yes	No	Yes	Yes	66.66%
Mostafa A et al[4], 2025	In vitro	3 days	No	No	Yes	Yes	Yes	No	50.00%
Saeed Nikanjam et al[29], 2024	In vitro	2 days	Yes	No	Yes	Yes	No	No	50.00%
Carolina et al[30], 2024	In vivo	4 days	No	Yes	Yes	No	No	Yes	50.00%
Sina Safari et al[31], 2024	In vitro	2 days	Yes	No	Yes	Yes	No	No	50.00%
Pushkar et al[32], 2024	In vitro	14 days	No	No	No	No	Yes	Yes	33.33%
Ghada et al[33], 2023	In vitro	3 days	No	No	Yes	Yes	No	No	33.33%
Asfia et al[34], 2022	In vitro	7 days	Yes	No	Yes	No	No	Yes	50.00%
Woraporn et al[35], 2021	In vitro	14 days	No	No	Yes	Yes	Yes	Yes	66.66%
Ayse et al[36], 2021	In vitro	2 days	Yes	No	No	No	Yes	Yes	50.00%
Jie Deng et, al[1] 2021	In vitro	14 days	Yes	No	Yes	No	No	No	33.33%
Kim et al[6], 2018	In vitro	14 days	Yes	No	Yes	Yes	Yes	No	66.66%
Maike Herla et al[11], 2019	In vitro	30 days	No	No	Yes	No	No	Yes	33.33%

Koteswara et al[37], 2015	In vitro	60 days	No	No	Yes	Yes	No	No	33.33%
Akanksha et al[15], 2013	In vitro	1 week	No	No	Yes	No	Yes	Yes	50.00%
Pragati et al[16], 2017	In vitro	7 days	No	No	Yes	No	Yes	No	33.33%
Kavita et al[38], 2017	In vitro	2 days	No	Yes	Yes	Yes	Yes	No	66.66%
Yoshihito et al[17], 2017	In vitro	4 days	Yes	No	Yes	No	No	Yes	50.00%
Pokpong et al[18], 2014	In vitro	2 days	No	No	Yes	No	Yes	Yes	50.00%
Tsubasa Naoe et al[19], 2020	In vitro	3 weeks	No	Yes	Yes	Yes	No	Yes	66.66%
Hina et al[20], 2022	In vitro	3 days	Yes	No	Yes	No	No	Yes	50.00%
Kensuke et al[21], 2018	In vitro	2 days	Yes	No	Yes	No	No	Yes	50.00%
Maryam et al[22], 2021	In vitro	3 days	Yes	Yes	Yes	Yes	No	No	66.66%
Dikshita et al[39], 2017	In vitro	7 days	No	Yes	Yes	Yes	No	No	50.00%
Hsin-Lin et al[40], 2018	In vitro	3 days	Yes	Yes	Yes	No	Yes	No	66.66%

reduced tensile bond strength and tear strength values, while these lower values were still within clinically acceptable range[36].

On the basis of few parameters risk of bias table is made. This table summarizes the risk of bias for each included study. Each study was reviewed across various domains to assess the possibility of bias affecting the validity of the outcomes.

Table 2: Risk of bias: An overview on materials development of denture tissue conditioner: a systematic review

CONCLUSION:

Recent developments in denture tissue conditioners, which aim to improve their mechanical properties, antifungal qualities, and biocompatibility, are a reflection of substantial improvements in materials science. Novelties include the use of natural extracts from plants, nanoparticles, and biocompatible polymer modifications have shown encouraging gains in patient convenience, durability, and clinical performance. Despite the abundance of in vitro research, high-caliber, long-term clinical trials are still desperately needed to confirm these results and evaluate their practicality. To guarantee the best possible oral health results for denture users, future research should concentrate on standardizing assessment methods and investigating sustainable materials.

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