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EVALUATION OF THE EFFECT OF 5.25% SODIUM HYPOCHLORITE AND 5% CHLORHEXIDINE DISINFECTANT SOLUTION ON VISCOELASTICITY, SURFACE HARDNESS AND COLOUR STABILITY IN ACRYLIC AND SILICONE BASED SOFT DENTURE LINERS- AN IN VITRO STUDY

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Abstract
BackgroundAnd Rationale
Soft denture liners in prosthetic dentistry are crucial for patient comfort and oral health preservation, but concerns about disinfectants' properties, viscoelasticity, surface hardness, and color stability have been raised.disinfection treatments, such as 5.25% sodium hypochlorite and 5% chlorhexidine, are commonly used to disinfect soft liners, but the impact on their physical properties is limited.
***Aim**:*
The study evaluates the impact of 5.25% sodium hypochlorite and 5% chlorhexidine disinfectant solution on viscoelasticity, surface hardness, and color stability of acrylic and silicone-based soft denture liners.
***Methodology**:*
Viscoelastic, surface hardness andcolor stability characteristics of silicone- and acrylic-based soft denture liners were examined in this work using tests and dynamic mechanical analysis. After being immersed in sodium hypochlorite for 15 minutes, the silicone-based group's liners had the maximum viscoelasticity, while the acrylic-based group's liners had the lowest viscoelasticity, according to the results. Disinfectant type also had an impact on surface hardness; sodium hypochlorite produced a harder surface than chlorhexidine. Silicone-based liners performed better in terms of color stability after being submerged in sodium hypochlorite. The evaluated groups' viscoelasticity, surface hardness, and color stability were found to differ significantly, with some comparisons showing statistical significance indicated by p-values.
Statistical Analysis:
Chi-square tests are used for qualitative analysis and independent t-tests were utilized for quantitative comparisons.
***Conclusion**:*
The study found that 5% chlorhexidine disinfection improved viscoelasticity and surface hardness of acrylic and silicone-based soft denture liners, while 5.25% sodium hypochlorite significantly affected viscoelasticity and surface hardness without significant color stability.

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I. Introduction

Soft denture liners are popular in prosthetic dentistry for patients with thin mucosa or severe alveolar resorption, providing cushioning, energy absorption, and durability.Dental prosthesis and appliances are urged to be disinfected before patient delivery and after intraoral use due to their susceptibility to microbial adhesion.Disinfection procedures are crucial to prevent cross-contamination risks in dental laboratory and clinical procedures, often involving chemical solutions like sodium hypochlorite and chlorhexidine.Sodium hypochlorite and chlorhexidine are known for their antimicrobial properties, but there is limited literature on their impact on the physical properties of soft liners.Soft denture liners' hardness, a key indicator of viscoelasticity, can cause discomfort, soreness, and tissue irritation due to increased occlusion forces on the underlying mucosa.Colour stability is crucial for dental materials, indicating aging or damage. Soft liners, especially acrylic ones, show color changes due to water absorption or solubilization.This study explores the impact of disinfection methods and denture cleansers on the physical properties of soft denture liners, despite the lack of research in this area.The study investigates the impact of cleansers on soft denture liners' hardness and color stability, aiming to optimize these materials for prosthetic dentistry. Surface topography influences attachment, rough surfaces promote colonization, and surface roughness contributes to plaque and biofilm formation. UV aging is suggested for accelerated aging. A comprehensive approach involving various factors that influence the aging of soft liners is inevitable. Theaimofthisinvitro study was to evaluate the parameters like viscoelasticity, surface hardness, and colour stability of soft denture-relining materials that have an effect after disinfection with 5.25 % sodium hypochlorite and 5% chlorhexidine.

II. Methodology:

Soft denture liners and tissue conditioners' efficacy is determined by their viscoelastic properties, which are assessed through penetration, static, and dynamic tests.This study evaluates viscoelastic, surface hardness, and color stability properties of ufigel-C acrylic-based auto-polymerized and mollosil silicone-based soft denture liners using dynamic mechanical analysis.

Viscoelasticity Evaluation:

The viscoelastic properties of soft denture liners and tissue conditioners are assessed through penetration, static, and dynamic tests, with dynamic mechanical analysis being most clinically useful. The test material's dynamic viscoelastic properties are assessed using an automatic viscoelastometer (RHEOVIBRON)

The rheological parameters namely the complex dynamic tensile modulus, storage modulus, loss modulus and loss tangent or respectively defined as

$E^* = E' + I E''$

$E' = |E^*| \cos §$

$E'' = |E^*| \sin §$

$\text{Tan}§ = E''|E'$

Where I is V-1 and § is the phase angle between the stress and strain.

Ten cylindrical specimens were created from each material to study viscoelastic properties. Silicone rubber patterns were embedded in gypsum, then removed and filled with acrylic resin-based denture liner dough.The cold-cured type soft denture liner specimens will be produced in a 20 mm in diameter and 20 mm in height cylindrical split Teflon mold, placed on a Mylar strip-covered glass plate. The mold was then filled with the mixed silicone-based product, covered with the Mylar strip and pressed flush with a glass plate.This procedure is done using viscoelastometer RHEOVIBRON measured in Pascal-second (pa.s)

Surface Hardness Evaluation:

The materials were processed according to manufacturer's instructions, ensuring uniform size and surface roughness through polymerization against the same glass surface.Petroleum Jelly was applied to a mold for easy removal, and the mold's back was placed on a glass slab covered with cellophane for separation. Soft denture liners were molded, covered with cellophane, and pressed against a glass slab to shape specimens.

All specimens were divided into three major groups based on cleansing treatments.
- Group A(sodium hypochlorite)
- Group B (chlorhexidine)

Comprising of 10 specimens each.
Each group was divided further into 6 subgroups:

Subgroups I, II, III, IV,V and VI(consisting of 10 specimens each) are to be tested at a time intervals of 1 week, 1 month, 3 months and 6 months respectively.

Each subgroup was again divided into two minor subgroups:
- Minor Subgroup a - consisted of samples made of acrylic-based soft denture liner
- Minor Subgroup b - consisted of samples made of silicone-based soft denture liner.

All specimens were cleaned daily. Specimens in Group A were immersed in 5.25% sodium hypochlorite solution for ten minutes daily.The study investigates the in vitro effects of plasticizer leaching on soft denture liners, designed for use with dentures in the oral cavity, focusing on the viscous, elastic, and co-polymer materials, such as plasticized acrylics and silicone rubber.The study suggests that the study's findings on denture lining materials may only partially predict clinical performance due to the nutrient-rich environment of the oral cavity. Further investigation into factors like absorption, solubility, roughness, bond strength, color stability, and viscoelastic properties is needed.This procedure is done using shore A durometer,measured in Newton per square millimeter (N/mm2).

Color Stabiltiy Evaluation:

This study processes soft lining materials from acrylic and silicon-based chemical types, as well as denture-based acrylic resin for both materials and specimens.A gypsum mold was created using a glass plate, partially filled with Parisian plaster, and kept clean on the upper surface.A rectangular wax was placed on a glass plate, covered with plaster mixture. The flask was filled, closed, and pressed for 30 minutes. The wax piece was removed, cleaned, and fixed to a glass plate. The wax was then painted with a separating medium.The study involved filling a flask with plaster, pressing it for 30 minutes, cleaning the mold, drying glass surfaces, painting gypsum surfaces, and packing soft materials in molds. Data was collected on ten specimens from different materials, analyzed for power differences, and immersed in (5.25%)sodiumhypochlorite.Disinfecting solution was evenly distributed in separate glass bowls, with equal volumes in each bowl and daily changes.The same batch of disinfectant solution was used throughout the experimental period of study. Color measurements for each specimen were taken with a colorimeter (NR-3000, Nippon Denshoku, Tokyo, Japan) before immersion in the disinfectant solution, and after 24 h and 7 days of immersion. Samples were stored in distilled water for 24 hours before color measurements. Device is calibrated with white plate, used as background to eliminate background colorvariations.The specimens were washed and air-spray dried before color measurements, which were performed using a colorimeter and measured in parts per million(ppm).

III. Results

The study evaluated the effects of disinfection on the viscoelasticity, surface hardness, and color stability of acrylic and silicone-based soft denture liners, with 60 samples per group. The study found that

1. The mean viscoelasticity and standard deviation values of Aarc andmolloplast in subgroup A1B1 specimens were 9.5+ 0.9 and 9.3 +1.1, respectively[table I, graph I].
2. The mean surface hardness and standard deviation values of Aarc and molloplast in subgroup A2B2 were found to be 8.0+ 0.9 and 7.7+ 1.3, respectively[table II graph II].
3. The specimen in subgroup A3B3 underwent 15-minute chlorhexidine immersion, resulting in mean color stability values of 5.6+1 and 8.1+1, respectively, with a p value of <0.01[Table III, graph III].
4. The mean viscoelasticity and standard deviation values of Aarc and molloplast in subgroup A4B4 specimens were 5.7+ 0.9 and 7.5+ 0.9, respectively, after 15 minutes of immersion in sodium hypochlorite[tableIV, graph IV].
5. Subgroup A5B5 specimens, immersed in 5.25% sodium hypochlorite for 15 minutes, showed mean surface hardness and standard deviation values of 5.4+0.9 and 7.2+0.7 respectively with p value <0.01[table V; graph V].
6. The specimen in subgroup A6B6 was exposed to 5.25% sodium hypochlorite for 15 minutes, resulting in mean color stability and standard deviation values of 10 +1.1 and 11.2+ 1.6 respectively with pvalue0.054 (P>0.05)[Table VI,graph VI]

As per the study ,highest mean surface hardness was found to be withsubgroup A5B5 and lowest mean surface hardness was found to be with subgroupA2B2.Subgroup A6B6 exhibited the highest mean color stability, while subgroup A3B3 had the lowest mean color stability.Independentttestwasusedtocomparequantitativeparameters between categories. It was found that the results were statistically significant with subgroups A3B3,A4B4,A5B5 as p value was <0.05. For Subgroup A1B1, A2B2,A6B6theresultswerestatisticallynonsignificantasp-valuewas>0.05.

StatisticalAnalysis

For all statistical interpretations, p<0.05 was considered the threshold for statisticalsignificance. The study employed an independent t test to compare quantitative parameters, while a Chi-square test was employed to identify associations between categorical variables in viscoelasticity,surface hardness and colour stability. Statistical analyses was performed by using a statistical software package SPSS, version 20.0.

IV. Discussion

Disinfection of acrylic and silicone-based soft denture liners is a significant issue in prosthodontic practice due to issues like loss of viscoelasticity, surface hardness, color stability, tear strength, water sorption, and inappropriate polymerization.The study examined two commonly used soft lining materials: (AARC) acrylic-based soft denture liners and (MOLLOPLAST) silicone-based soft denture liners.Samples were disinfected with chlorhexidine and sodium hypochlorite for 15 minutes at 37°C. Standard hygiene for removable prosthetic restorations recommends soft lining materials for improved comfort, as elastomeric materials are susceptible to elasticity loss and require costly replacements.Jones et al. identified eight chemicals as plasticizers for soft lining materials, used in varying amounts from 26% to 51% by mass.Kaul et al. found that ionized solutions accelerate the release of plasticizers, with sodium and potassium ions being particularly effective in soft lining materials.The research indicates that acrylic elastomers are highly sensitive to disinfecting solutions, a finding that has been confirmed by other authors' observations.Villacryl Soft's VEC value nearly doubled after 28 days, while Vertex Soft's average Viscoelastic value increased by 0.2 MPa in sodium hypochlorite solution, due to artificial saliva's elasticity change.Ethylene glycol dimethacrylate is used in storage solutions to improve cross-linking in silicone and acrylic materials, but its release can indicate incomplete or unstable cross-links, requiring regular hygiene.Limit mechanical brushing on dentures to prevent lining material damage, use disinfectants instead, but be cautious about releasing phthalic acid esters, which could act as xenoestrogens.Gas Chromatography/Mass Spectrometry studies have determined compounds released from soft lining materials, revealing that between 0.02% and 0.38% of the material can be leached into aqueous media.Artificial saliva significantly lost weight in high temperature polymerized materials, while sodium hypochlorite affected room temperature materials. Disinfectants affected elastomeric, surface hardness, and color stability. Soft liners contained Ethyl glycol mehtacrylate in chlorhexidine and sodium hypochlorite solutions, while silicone materials were more stable.The study found EGDMA in all silicone solutions, except for Mollosil samples in artificial saliva, and found methyl methacrylate and n-didocyl methyl in storage solutions of Molloplast B, irrespective of polymerization type.Cylindrical specimens were prepared from a custom-made metal mold with dimensions of 14 mm × 2 mm (According to ASTM: D-2240-64T), and a glass slab was placed over another slab coated with petroleum jelly for easy removal.Soft denture liners were molded, covered with petroleum jelly, and shaped. They were set, removed, trimmed, and cured in a water bath before being carefully removed and trimmed for data collection.The study collected data on ten specimens from each material, and conducted a power analysis (using G*Power Version 3.1.5) to determine the required number of specimens for each test group.Specimens were immersed in sodium hypochlorite(5.25%)(NationalCleaningProductsCompany,haryana)and 5% chlorhexidine (Relief lab private limited, Hyderabad) . The participants were immersed in a glass beaker filled with disinfecting solution, using equal volumes and the same batch throughout the experimental study period.

Viscoelasticity

Test methods like oscillating rheometers, cone plate type rheometers, dynamic mechanical analyzers, and creep meters assess viscoelastic properties, interpreting them as Voigt four-element model characteristics, determining elastic deformation of serial spring.The displacement of h2 and h3 after load application, known as delayed elastic displacement, represents the elastic deformation of the parallel connected spring and dashpot elements.The viscous flow of soft liners, whether acrylic resin-based or silicone-based, was found to have a water sorption and solubility of 0.9-1.2 and 0.7-3.4%, respectively.The viscoelastic properties of soft denture liners can be significantly affected by the elution of plasticizer components during storage in water, according to previous research.Viscoelastic properties were measured using a creep meter (Anton paar, modular compact rheometer, Tokyo, Japan). The specimen was loaded with a 3-mm probe at 1 mm/s until a final load of 1.96 N was reached, then the probe's displacement was continuously recorded until 120 s.The viscoelastic parameters, including instantaneous, delayed, viscous flow, and residual displacement, were calculated using the Voigt four-element model and a software program (Creep Analysis Ver.1.3, Yamaden).Denture disinfectants affect elastic lining materials' properties, releasing compounds and reducing elasticity. However, materials stored in artificial saliva, dry, or exclusively in artificial saliva showed minimal change.AARC and MOLLOPLAST soft liners showed less elasticity loss compared to silicone materials, with substances released within European limits. Chemical disinfection with 5.25% Sodium hypochlorite solutionsignificantly reduced viscoelasticity, while 5% chlorhexidine solution did not.

SurfaceHardness

Resilient materials' hardness, which should remain consistent over time, can beaffected by factors like temperature, with acrylics showing more negative effects than silicone.The study measured surface hardness using a Shore A Durometer calibrated to 822 gf (8.06 N), revealing changes in soft lining substances like plasticizers and monomers.The Shapiro-Wilk analysis revealed a normal distribution of hardness values in the investigated groups, while ANOVA revealed no significant differences between the examined groups.The study found that soft liner samples' surface hardness increased significantly when cleansed with 5% chlorhexidine and

5.25% sodium hypochlorite, despite variations in cleaning tablets, sample sizes, and storage durations, while resilient liner's hardness remained unaffected.This study aligns with a 2013 study by Pahuja et al., which found an increase in the shore A value of acrylic resilient liner in sodium hypochlorite and chlorhexidine groups.Mohammed et al.'s 2016 study found that self-cured acrylic and silicone resilient liners' hardness increased when submerged in cleansing tablets.Chemical disinfection with 5% chlorhexidine solution did not significantly reduce the surface hardness of acrylic and silicone-based soft liner MOLLOPLAST(subgroup A2B2) while 5.25% sodium hypochlorite solution significantly reduced the surface hardness of acrylic and silicone soft liner MOLLOPLAST(subgroupA5B5).

ColourStability

Color measurements were taken using a colorimeter (Thermoscienticevolution , one plus, Tokyo, Japan) after immersion in disinfectant solution. The device was calibrated with a white calibration plate, and the white calibration standard plate was used as the background during data collection.This study processed soft lining materials from plasticized acrylic resin and silicone-based materials, along with a denture base acrylic resin. A glass plate was applied to the bottom of a glass slab flask filled with soft liner materials.Soft liner materials were pressed, dried, and painted, then processed in a water bath. A Bonferroni test showed insignificant changes in acrylic-based liner values after immersion.The acrylic-based liner showed a higher increase in values after immersion compared to silicone-based liner, and color changes in soft denture liners increased with longer immersion times.Disinfectants were used in glass bowls, calibrated, and specimens washed and air-dried before color measurements. A lens was applied to the glazed surface..Chemical disinfection with 5% chlorhexidine solution significantly reduced the color stability of acrylic and silicone-based soft liners AARC and MOLLOPLAST(subgroup A3B3), while 5.25% sodium hypochlorite solution did not significantly affect color stability of AARC and MOLLOPLAST(subgroup A1B1)

V. Conclusion

Withinthelimitationsofthepresentstudy,itwasconcludedthat disinfecting with 5% chlorhexidine did not significantly affect the viscoelasticity and surface hardness of acrylic and silicone-based soft denture liners. However, it significantly affected the color stability. When disinfected with 5.25% sodium hypochlorite, the viscoelasticity and surface hardness were significantly affected, but no significant color stability was observed. Therefore, 5% chlorhexidine disinfection is recommended for viscoelasticity and surface hardness, while 5.25% sodium hypochlorite is safer for color stability.