(International Print/Online Journal)
SJIF IMPACT FACTOR: 5.565
PUBMED-National Library of Medicine ID-101739732
ISSN (Print): 2209-2870
ISSN (Online): 2209-2862
International Journal of Medical Science and Current Research (IJMSCR)
Available online at: www.ijmscr.com
Volume 5, Issue 3, Page No: 185-193
May-June 2022
IJMSCR

# Retentive Ability And Viscosity Of Denture Adhesives Incorporated With Antimicrobials – An In Vitro Study

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Type of Publication: Original Research Paper
Conflicts of Interest: Nil

**Abstract**

**Purpose:** This study aims to compare and evaluate denture adhesives' viscosity and retentive ability incorporated with four different antimicrobials.

**Materials and Methods:** Two commercially available denture adhesives (FIXON and SECURE) in powder and cream formulations were used. The antimicrobials used in the study were nystatin, cephalexin, chlorhexidine digluconate, and silver nanoparticles. The viscosity was measured using a rotary rheometer, and retentive ability was determined using a Universal testing machine.

**Results:** Antimicrobials (cephalexin, nystatin, 2% chlorhexidine, and silver nanoparticles) did not alter the viscosity and retentive ability of denture adhesives significantly at 1% concentrations. The addition of 2% chlorhexidine digluconate in denture adhesive powders significantly increased the viscosity and retentive ability.

**Conclusions:** Within this study's limitations, it can be concluded that chlorhexidine digluconate and silver nanoparticles can be viable antimicrobial therapies in denture adhesives. Cream formulations showed significantly higher retentive ability and viscosity than powder formulations.

**Keywords**: Denture adhesives, Chlorhexidine digluconate Silver nanoparticles, Viscosity, Retentive ability.

## Introduction:

Edentulism continues to be a prevalent condition worldwide among the elderly. Even though implant-supported overdentures are being explored as an alternative, conventional muco-supported dentures are still the staple treatment modality. The use of denture adhesives has also increased among complete denture wearers. By 1939, there were some 15 million denture wearers and numerous manufacturers of denture adhesives.[1] Denture adhesives are primarily used to bond and retain dentures to the denture bearing area. Numerous studies stated that denture adhesives significantly reduced the lateral and vertical movement of the dentures.[2–4] They are also known to improve taste perception and articulation[5], decrease food accumulation under denture[6] and boost patient confidence, and provide psychological comfort. They are also used to stabilize trail bases during prosthesis fabrication and trail denture insertion.[7] They are also indicated in patients with poor neuromuscular control and those with dry mouth or xerostomia. Despite their widespread use, many dentists were slow to accept denture adhesives as an auxiliary agent to retain dentures. This might be partly because denture adhesives support microbial growth, causing denture stomatitis and candidiasis.

The purpose of this in vitro study is to compare and evaluate the retentive ability and viscosity of denture adhesives incorporated with four antimicrobials (nystatin, cephalexin, chlorhexidine digluconate, and silver nanoparticles).

**Materials And Methodology:**

Two commercially available denture adhesives (FIXON and SECURE) in powder and cream formulations were used. The antimicrobials used were nystatin, cephalexin, 2% chlorhexidine digluconate, and silver nanoparticles (80nm). Samples were prepared using DPI. Heat-cure acrylic material. Medium-body polyether impression material (Impregum) along with artificial saliva were used to simulate oral mucosa. The total sample size taken was 200 and was divided into the following groups: (Figure 1).

**Viscosity measurement:** The viscosity of denture adhesive samples was determined using a rotary rheometer (Brookfield, Middleboro, MA). For this, 3 grams denture adhesive is thoroughly mixed with 0.03 grams of each antimicrobial (1%) and with 0.5 ml of distilled water in a clean glass plate. For control samples, 3.03 grams of denture adhesive was mixed with 0.5ml of distilled water. Then the samples were directly placed on the rheometer plate, and the measurements were recorded.

**Retentive ability measurement:** The retentive ability was measured according to ISO – 10873 guidelines. The sample holders were made with heat-cure acrylic material. The sample holder (Diameter 22mm, Depth 0.5mm) was filled with denture adhesive samples (controls and samples incorporated with antimicrobials), and the surface was flattened. To simulate oral mucosal conditions, polyether (medium viscosity impression material) was used in the pressure-sensitive knob. The pressure-sensitive knob with polyether was fixed on the sample holder. Artificial saliva was used as an interfacing medium. A load of 9.8 ± 0.2 N was applied to the sample using a constant load compression testing machine at a pressurizing velocity of 5 mm/min using a 20 ± 0.5 mm pressure and maintained for 30 s. The sample was then pulled in the reverse direction with tensile velocity using an Instron Universal testing machine at a 5 mm/min crosshead speed.

**Results:**

The viscosity (Pa-s) was assessed with a rotary rheometer, and retentive ability (kPa) was measured with an Instron Universal testing machine. The numbers presented were mean and standard deviation of the samples' values of viscosity and retentive ability (Table 1). The statistical analysis was performed using Statistical Package for the Social Sciences (SPSS) version 15.0, the statistical analysis software. The data were analyzed by analysis of variance test (ANOVA).

The values of viscosity in FIXON and SECURE Powder for controls (2635, 2669.4), with cephalexin (2640.2, 2663.4), with nystatin (2642.4, 2685.1), with chlorhexidine (3271, 3275.9), and with silver nanoparticles (2647.4, 2686.4). There was an increase in viscosity in samples incorporated with chlorhexidine in both denture adhesive powder brands. Similarly, the retention values also showed a rise in powders with chlorhexidine (35.5, 35.9) than those of controls (28.5, 28.5), with cephalexin (28.1, 28.5), with nystatin (28.1, 28.1), and with silver nanoparticles (28.2, 28.1). When the ANOVA test analyzed these values, the results showed a statistically significant ($p$-value $< 0.00001$) increase in viscosity and retention in both denture adhesive powders with chlorhexidine.

For cream formulations, the ANOVA test showed no statistical significance in viscosity and retention of controls and those incorporated with antimicrobials for both the denture adhesive creams (Table 1).

Pair-wise comparisons were made by Post-hoc Scheffe's statistic test for powder formulations. (Table 2). The results showed that viscosity and retention values in samples incorporated with chlorhexidine were significantly higher than controls and those with cephalexin, nystatin, and silver nanoparticles.

The results of the comparisons between powder and cream formulation showed that the viscosity and retentive values are significantly higher for cream-type adhesives than powder type of adhesives. There was no significant difference in viscosity and retentive ability among both the denture adhesive brands (Table 3).

**Discussion:**

Adequate retention is an essential requirement for the acceptance of complete dentures by the patient.

Denture adhesives have long been used to provide comfort and a sense of security to the patient. The use of denture adhesives is increasing among the complete denture wearers. It is reported that 15% of U.S. denture wearers used adhesives in the 1980s,[8] while in 1990, 30% of denture wearers used or had used denture adhesives.[9]

Currently, numerous companies are supplying denture adhesives in soluble forms (creams, pastes, and powders) and insoluble forms (pads and synthetic wafers). Denture adhesives contain active ingredients (water-soluble polymers) and non-active ingredients (base material). The active ingredients primarily include carboxymethylcellulose (C.M.C.), polyvinyl ether methylcellulose (PVM-MA), and other carbohydrates. The non-active ingredients include petrolatum, mineral oil, and polyethylene oxide, mainly binding materials to facilitate placement.[10] Due to the presence of sugars, flavoring, and sweetening agents in these adhesives, they have gained negative reviews from a vast number of clinicians. The flavoring agents act as a medium for the growth of various fungi like *Candida albicans* and *Candida tropicalis* and can cause denture stomatitis.

Studies have shown that denture adhesives containing antiseptics like p–hydroxybenzoic acid methyl ester and propylparaben had no inhibitory effect on the growth of *Candida albicans*.[11] Bates et al. suggested that inclusion of antifungal antibiotics (nystatin, amphotericin B, Flucanozole, chlorhexidine gluconate, and chloride) to denture adhesives aid in a significant decrease of candidal infections and denture stomatitis.[12] Our previous study evaluated the antimicrobial efficacy of cephalexin, nystatin, 2% chlorhexidine gluconate, and silver nanoparticles against the growth of two microorganisms – *Candida albicans* and *Streptococcus mutans*. The results of our study showed that 2% chlorhexidine digluconate and silver nanoparticles could be possible antimicrobial additions to denture adhesive's composition. Both silver nanoparticles and 2% chlorhexidine gluconate significantly reduced the growth of *C.albicans* and *S.mutans*.

In the present study, the viscosity and retentive ability of denture adhesives incorporated with cephalexin, nystatin, 2% chlorhexidine gluconate, and silver nanoparticles were studied. Viscosity and retentive ability are important properties of denture adhesives that govern their ease of use and clinical efficacy. When adhesives are placed in the mouth, they become viscous and sticky due to water absorption. This water absorption occurs through the water-soluble polymer. In general, high viscosity provides more retention. But high viscosity of denture adhesives makes it tough and challenging to manipulate and handle.[7] An ideal denture adhesive should possess a low initial viscosity, which allows easy manipulation and better handling property, followed by high viscosity to maximize retention.[13].

Oral mucosa is viscoelastic in nature. Hence, medium-body polyether impression material (Impregum) was used to simulate the surface energy of oral mucosa. In addition, polyether is a hydrophilic impression material. Artificial saliva was used as an interfacing medium.

In the present study, the viscosity of two powder type and two cream type denture adhesives was studied. The results showed that the viscosity and retentive values are significantly higher for cream-type adhesives than powder type of adhesives. These findings were consistent with the results of previous studies. Chew reported that cream-type denture adhesives significantly improved the retention between acrylic disc and rat skin than powder and seat-type denture adhesives.[15] Similar results were reported by Uysal et al. [16] and Kulak et al. [17] who also recommended the use of cream adhesives than powder adhesives.

When samples incorporated with antimicrobials were compared, only the denture adhesive powders incorporated with chlorhexidine showed significantly higher viscosity and retentive values than controls and those incorporated with cephalexin, nystatin, and silver nanoparticles. No such significance was seen among samples of denture adhesive creams. The reason for this may be due to the addition of 2% chlorhexidine digluconate in liquid form. The dissolution reaction of the water-soluble polymer has already begun in powder-type adhesives. And, the addition of distilled water and chlorhexidine in the liquid form further accelerated this process to attain a paste-like consistency of the samples. All other antimicrobials being added in powder form didn't show such an increase in viscosity and retention.

In the cream type of denture adhesives, although the values were higher than concomitant powder types, the addition of chlorhexidine didn't show any increase as in powder forms. This may be because there was no ready dissolution of distilled water or chlorhexidine in cream-type denture adhesives like-wise in powder types.

The present study results showed that denture adhesives' viscosity and retentive ability were not altered significantly when antimicrobials were added to them. Hence these antimicrobials incorporations can be considered. And, 2% Chlorhexidine digluconate and silver nanoparticles can be used as viable antimicrobial addition in denture adhesive's composition.

**Limitations:**

1. As it is an in vitro study, the biologic environment of the oral mucosa could not be simulated.
2. The viscosity and retentive values need to be studied for longer durations to understand their efficacy better.
3. Systemic influence and cytotoxicity of silver nanoparticles should be evaluated.

**Conclusions:**

Within the limitations of the study, it can be concluded that,

1. Antimicrobials (cephalexin, nystatin, 2% chlorhexidine, and silver nanoparticles) did not alter the viscosity and retentive ability of denture adhesives significantly at 1% concentrations.
2. 2% Chlorhexidine digluconate and silver nanoparticles can be used as possible antimicrobial incorporations in denture adhesives.
3. Cream formulations showed significantly higher retentive ability and viscosity than powder formulations.

**Figure 1 : Schematic Representation of Distribution of Samples (n=200)**

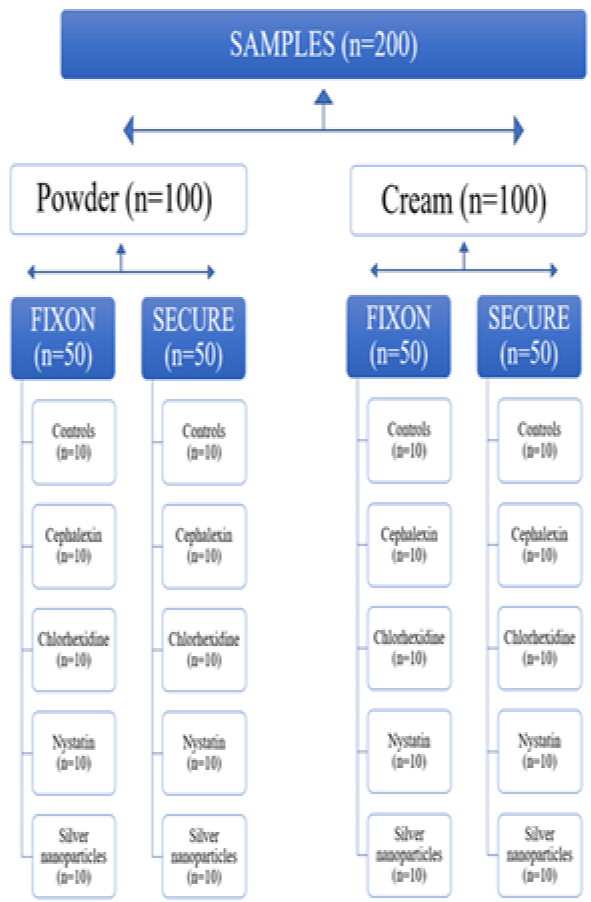


**Figure 2 : Heat cure acrylic samples and pressure sensitive knob with polyether**

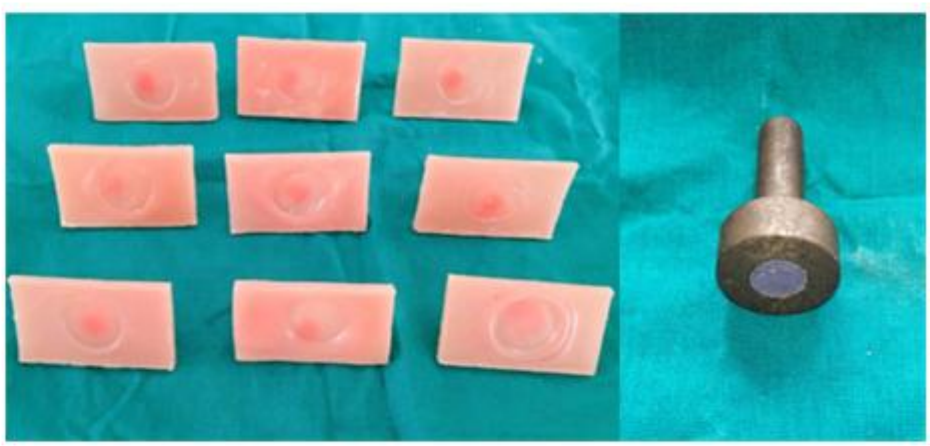

**Figure 3 : Rotary rheometer (Brookfield, Middleboro, MA) and Universal testing machine (INSTRON)**


**Table 1 : Comparison of Viscosity and Retentive ability of samples by One-way ANOVA analysis**

| SAMPLE | Group | VISCOSITY (Pa-s) | | | | RETENTIVE ABILITY (kPa) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Mean | SD | f-ratio value | p-value | Mean | SD | f-ratio value | p-value |
| FIXON POWDER | Control | 2635 | 63.0507 | 73.92 | 0.00001 | 28.5 | 4.9318 | 6.3914 | 0.0004 |
| | Cephalexin | 2640.2 | 158.5313 | | | 28.1 | 5.0651 | | |
| | Nystatin | 2642.4 | 122.1722 | | | 28.1 | 13701 | | |
| | Chlorhexidine | 3271 | 34.053 | | | 35.5 | 3.3417 | | |
| | Silver Nanoparticles | 2647.4 | 91.9108 | | | 28.2 | 4.2895 | | |
| SECURE POWDER | Control | 2669.4 | 63.1844 | 145.91 | 0.00001 | 28.5 | 1.9003 | 8.444 | 0.000036 |
| | Cephalexin | 2663.4 | 30.4018 | | | 28.5 | 4.3525 | | |
| | Nystatin | 2685.1 | 103.1476 | | | 28.1 | 4.5326 | | |
| | Chlorhexidine | 3275.9 | 70.577 | | | 35.9 | 3.035 | | |
| | Silver Nanoparticles | 2686.4 | 64.457 | | | 28.1 | 4.401 | | |
| FIXON CREAM | Control | 4390.1 | 65.3613 | 0.0524 | 0.994 | 40.2 | 2.2509 | 0.393 | 0.812 |
| | Cephalexin | 4398.7 | 64.4447 | | | 39.3 | 2.2136 | | |
| | Nystatin | 4390.3 | 100.8366 | | | 39.8 | 2.044 | | |
| | Chlorhexidine | 4387.4 | 103.2098 | | | 39.3 | 2.2136 | | |
| | Silver Nanoparticles | 4382 | 75.7574 | | | 39 | 3.1269 | | |
| SECURE CREAM | Control | 4403.9 | 52.4541 | 0.0804 | 0.988 | 40.4 | 2.011 | 0.4382 | 0.7803 |
| | Cephalexin | 4401.4 | 101.6379 | | | 39.2 | 1.8738 | | |
| | Nystatin | 4409.1 | 78.976 | | | 39.2 | 4.0497 | | |
| | Chlorhexidine | 4390.3 | 100.8366 | | | 39.1 | 2.1318 | | |
| | Silver Nanoparticles | 4406.7 | 60.314 | | | 39.2 | 2.4404 | | |



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**Table 2 : Comparison by Post-hoc Scheffé Analysis for Powder formulations**

| Treatment Pairs | TT-statistic | | | | Inference |
|---|---|---|---|---|---|
| | Viscosity | | Retentive Ability | | |
| | FIXON POWDER | SECURE POWDER | FIXON POWDER | SECURE POWDER | |
| Control vs Cephalexin | 0.1015 | 0.1909 | 0.4433 | 0 | insignificant |
| Control vs Nystatin | 0.149 | 0.4996 | 0.4433 | 0.2414 | insignificant |
| Control Vs Chlorhexidine | 13.7194 | 19.2985 | 3.6571 | 4.4662 | ** p<0.01 |
| Control vs Silver Nanoparticles | 0.2569 | 0.5409 | 0.3879 | 0.2414 | insignificant |
| Cephalexin vs Nystatin | 0.0475 | 0.6905 | 0 | 0.2414 | insignificant |
| Cephalexin vs Chlorhexidine | 13.6179 | 19.4894 | 4.1004 | 4.4662 | ** p<0.01 |
| Cephalexin vs Silver nanoparticles | 0.1554 | 0.7318 | 0.0554 | 0.2414 | insignificant |
| Nystatin vs Chlorhexidine | 13.5704 | 18.7989 | 4.1004 | 4.7076 | ** p<0.01 |
| Nystatin vs Silver nanoparticles | 0.1079 | 0.0414 | 0.0554 | 0 | insignificant |
| Chlorhexidine vs Silver nanoparticles | 13.4625 | 18.7576 | 4.045 | 4.7076 | ** p<0.01 |

**Table 3 : Comparison of Viscosity and Retentive ability of samples by Student "t" Tests**

| VISCOSITY | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Treatment Pairs/ Samples | FIXON POWDER vs CREAM | | SECURE POWDER vs CREAM | | FIXON POWDER vs SECURE POWDER | | FIXON CREAM vs SECURE CREAM | |
| | t value | p value | t value | p value | t value | p value | t value | p value |
| Controls | -61.096 | <0.00001 | -66.792 | <0.00001 | -1.2 | insignificant | -0.52 | insignificant |
| Cephalexin | -32.495 | <0.00001 | -51.806 | <0.00001 | -0.454 | insignificant | -0.07 | insignificant |
| Nystatin | -34.892 | <0.00001 | -41.965 | <0.00001 | -0.844 | insignificant | -0.464 | insignificant |
| Chlorhexidine | -32.482 | <0.00001 | -28.631 | <0.00001 | -0.197 | insignificant | -0.063 | insignificant |
| Silver nanoparticles | -46.299 | <0.00001 | -61.626 | <0.00001 | -1.098 | insignificant | -0.813 | insignificant |
| RETENTIVE ABILITY | | | | | | | | |
| Treatment Pairs/ Samples | FIXON POWDER vs CREAM | | SECURE POWDER vs CREAM | | FIXON POWDER vs SECURE POWDER | | FIXON CREAM vs SECURE CREAM | |
| | t value | p value | t value | p value | t value | p value | t value | p value |
| Controls | -6.591 | <0.00001 | -13.6 | <0.00001 | -0.239 | insignificant | -0.209 | insignificant |
| Cephalexin | -6.407 | <0.00001 | -7.14 | <0.00001 | -0.189 | insignificant | -0.109 | insignificant |
| Nystatin | -15.035 | <0.00001 | -5.774 | <0.00001 | 0 | insignificant | -0.418 | insignificant |
| Chlorhexidine | -2.997 | <0.00001 | -2.728 | <0.00001 | -0.28 | insignificant | -0.205 | insignificant |
| Silver nanoparticles | -6.433 | <0.00001 | -7.436 | <0.00001 | -0.053 | insignificant | -0.159 | insignificant |

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