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Comparative Evaluation of Effectiveness of Denture Adhesive after Incorporating Antifungal Agent – An *In-vitro* Study

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Authors' contributions

This work was carried out in collaboration among all authors. Authors JM and TR designed the study, wrote the protocol, data collection and wrote the first draft of the manuscript. Author PSN edited the manuscript, performed the statistical analysis, managed the literature searches and managed the analyses of the study. Authors SS, NA and KN managed the literature searches and managed the analyses of the study. All authors read and approved the final manuscript.

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ABSTRACT

Aims: The aim of current study is to evaluate adhesive force and qualitative mycological culture analysis of Denture adhesive (DA) after incorporating antifungal agent in various concentrations.
Study Design: Experimental study.
Place and Duration of Study: The current study was conducted at the Department of Prosthodontics, Mansarovar Dental College and Hospital, Bhopal (M. P.) from September 2017 to October 2018.
Methodology: A total of 80 specimens were prepared with heat cured acrylic resin, out of which 40 were used for qualitative anti-microbiological test, and 40 were used for Adhesive force measurement test. Both test had four groups: Group A (Control group DA without MN); Group B (DA+MN 10%); Group C (DA+MN 20%); and Group D (DA+MN 30%).

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Results: The mean zone of inhibition was *8.85 ± 0.28* mm for 10% w/w Miconazole Nitrate (MN), *12.95±0.30* mm for 20% w/w MN, and *22.25 ± 0.38* mm for 30% w/w MN. There was a statistically highly significant (*P< .001*) difference between the groups, with an F value of *1077.8*.
Conclusion: Within the limitation of the study qualitative *anti-microbial* property for favorable laboratory performance can be achieved only after the addition of 20% w/w Miconazole Nitrate to denture adhesive paste.

Keywords: Anti-microbial; adhesive force; PMMA; removable maxillary denture; retention; universal testing machine.

ACRONYMS & ABBREVIATIONS

PMMA = Polymethyl methacrylate
DA = Denture adhesive
MN = Miconazole nitrate
DS = Denture stomatitis

1. INTRODUCTION

Oral cavity pathogens live in a complex habitat and immunological components that maintain the mouth healthy and free of illness keep these infections in check. Denture Stomatitis (DS) is the most frequent illness. The term "denture stomatitis" was coined by Cahn (1936). DS is an inflammation of the mouth caused by removable dentures. Symptoms include discomfort, burning, and a foul taste [1]. People with DS often have no symptoms and are unaware they have it. Traditionally, clinical symptoms were categorized by inflammation [2].

Newton [2-4] first established a scale for grading DS inflammation. Candida species, particularly *Candida albicans*, are suspected of causing denture stomatitis, affecting 40-60% of people [5-7]. These organisms colonized and infect the denture fitting surface rapidly, producing direct cytotoxicity and activating acid proteinase and phospholipase produced by these yeasts, increasing *Candida albicans* proliferation [2,4,6-9]. Other organism, such as *Candida glabrata* [9-14], may be responsible for the sickness. *Candida albicans* thrives on the nutrient-rich surface of denture tissue [6].

Arendorf and Walker claim that 40% of healthy individuals have oral commensal. Candida might be opportunistic in denture users because dentures impede the passage of oxygen and saliva to the underlying tissue, resulting in an acidic and anaerobic environment that encourages yeast growth. *C. Albicans* colonization, plaque formation, and pathogenicity rely on solid surfaces such as acrylic resin for survival. Early yeast adhesion is affected by hydrophobic [15] (van der Waal forces) and electrostatic forces [16].

Denture adhesives (DA) are often used to improve denture retention and stability [17]. These materials come in powder, strip, cream, and cushion forms. Water-soluble polymers with mucoadhesive characteristics and essential components make up DA cream [17-18]. Mucoadhesion may be used to provide sustained oral drug release [19-21]. They may remain on the mucosa longer, enhancing pharmaceutical absorption [22]. They outperform commercial gel antifungal formulations [23].

Denture wearers may maintain DA for 6–8 hours and the layer of DA is susceptible to candidal infection. To avoid this, DA may release antimicrobial compounds like Miconazole nitrate (MN) without affecting its mucoadhesive properties [24]. According to Scher EA *et. al.,*and Leite AR *et. al.,* some denture adhesives are already antimicrobial [25].

Miconazole nitrate (MN) is a first-line broad-spectrum triazole for superficial mucosal Candidiasis. Oral mycoses have been treated using MN that is commercially available in various form e.g. Gel [26], chewing gum [27], bio-adhesive films [28], buccal patches [22], buccal tablets [29], and spray-dried polymeric micro particles of MN with enhanced drug solubility & antifungal activity [30]. MN oral gel is globally sold and has a short contact time (6-8 hours) [31,32]. There were very few studies conducted on DA with antifungal agents, but optimum concentration should be established without affecting adhesive force of DA.

The aim of the present research was to evaluate and compare the adhesive force and antifungal property of denture adhesive (DA) paste after incorporating antifungal agent Miconazole Nitrate (MN) with heat polymerized denture base resin at various concentrations. The null hypothesis was there were no differences between all groups in

term of antifungal property and adhesive force of DA.

Provide a factual background, clearly defined problem, proposed solution, a brief literature survey and the scope and justification of the work done.

2. MATERIALS AND METHODS

The current study was conducted at the Department of Prosthodontics, Mansarovar Dental College, Hospital & Research Centre, Bhopal (M. P.) from September 2017 to October 2018. According to Cartagena AF et al. [33] Sample size of 10 in each group was determined with 95% confidence interval, 80% power of test, with absolute precision of 4.0.

2.1 Specimens Preparation

Stainless Steel cylinder die of size 75.0 x 12.0 mm were fabricated to create the test samples for Adhesive force measurement test. Stainless Steel disc die of size 2 mm x 0.5 mm were fabricated to create the test samples for anti-microbiological test. A total of 80 specimes were prepared with heat cured acrylic resin (Trevalon denture base material by Dentsply), forty were used for anti-microbiological test and forty were used for Adhesive force measurement test.

2.2 Denture Adhesive Preparation

For present study formulations of denture adhesive (Fixon super grip cream, IPCA Health Products, Mumbai, India) and miconazole nitrate (Detrain, J.K pharmaceutical company, Chennai, India) in various concentration was obtained by weighing different concentration i.e. 10%, 20%, 30% w/w in electronic balance followed by mechanical mixing. Both tests had four groups: Group A (Control group DA without MN); Group B (DA+MN 10%); Group C (DA+MN 20%); and Group D (DA+MN 30%).

2.3 Anti-Microbial Test

The antimicrobial evaluation for all four groups was done according to Cartagena AF et al. [33] after 24 and 48 hrs.

2.4 Adhesive Force Measurement

The evaluation of Adhesive force was done for all specimens described by Cartagena AF *et. al.* [33] after 6 hours and 12 hour by using Universal Testing Machine (Fuel Instruments & Engineers Pvt. Ltd., Kolhapur, Maharashtra, India).

2.5 Statistical Analysis

The obtained data were subjected to One way ANOVA and Turkey-Kramer multiple comparison test ($\alpha = 0.05$) for statistical analyses using SPSS for windows (IBM SPSS Statistics, v20; IBM Corp, Armonk, N.Y., USA).

3. RESULTS

3.1 Result of Microbiological Assay

The mean and standard deviations of zone of inhibitions in different groups was given in Table 1. There was a statistically highly significant (*P*< *.001*) difference between the groups, with an F value of 1077.8.

Miconazole Nitrate 30% (Group - D) significantly increased antimicrobial activity. (Table 1) The one way ANOVA test was used to compare various Miconazole Nitrate concentrations. The test result indicates that there was a significant difference between the control and Miconazole Nitrate 10%, 20%, and 30% groups. This indicates that raising the proportion of Miconazole Nitrate resulted in a substantial increase in antimicrobial activity. (Table 2).

3.2 Result of Adhesive Force Measurement

The Turkey-Kramer multiple comparison test was used to determine the differences in adhesive force between groups. The mean adhesive force in the control group was 18.10 ± 2.55 N, whereas the mean adhesive force in the Miconazole Nitrate 10% w/w group was 7.55 ± 0.98 N, the mean adhesive force in the Miconazole Nitrate 20% w/w group was 5.85 ± 0.74 N, and the mean adhesive force in the Miconazole Nitrate 30% w/w group was 4.6 ± 0.61 N. The test result indicates that a substantial difference existed between the groups. This indicates that the adhesive force was significantly reduced after the addition of Miconazole Nitrate. There was a statistically highly significant (P< .001) difference between the groups, with F = 1077.8. (Table 4).

4. DISCUSSION

Due to its ease of manipulation and cheap cost, polymethyl methacrylate (PMMA) has been the most commonly used denture base material. Despite its widespread use, PMMA's characteristics remain insufficient. The durability

of removable dentures is significantly impacted by fractures or microbial growth. Microorganism colonization and subsequent biofilm formation on the denture surface are significant contributors to the development of denture stomatitis (DS), which is potentially a public health issue.

Table 1. Evaluation of Zone Of Inhibition (mm) between different groups of DA+MN

I D no.	Group – A (Mean±SD)	Group – B (Mean±SD)	Group – C (Mean±SD)	Group – D (Mean±SD)
Am1	0±0	8.0±2.82	13.0±1.41	21.5±2.12
Am2	0±0	8.25±1.76	13.5±2.12	22.5±2.12
Am3	0±0	9.0±2.82	12.5±2.12	24.5±2.12
Am4	0±0	10.0±2.82	13.5±3.53	21.5±2.12
Am5	0±0	10.0±4.24	14.5±3.53	20.5±2.12
Am6	0±0	8.0±2.12	12.0±4.24	22.5±3.53
Am7	0±0	7.75±1.76	14.0±2.82	23.5±3.53
Am8	0±0	8.5±2.12	12.0±2.82	23.0±4.24
Am9	0±0	9.0±1.41	11.5±3.53	21.0±4.24
Am10	0±0	10.0±2.82	13.0±2.82	22.0±2.82

Table 2. One way ANOVA test for comparing the zone of inhibition (mm) between different groups of DA+MN

Source of variation	Degree of freedom	Sum of squares	Mean square	F-value	P-value
Treatment (between columns)	3	2559.9	853.29	1077.8	*<0.001**
Residual (within columns)	36	28.500	0.7917		
Total	39	2588.4			

Table 3. Evaluation of adhesive force (N) between different groups of DA+MN

I D no.	Group – A (Mean±SD)	Group – B (Mean±SD)	Group – C (Mean±SD)	Group – D (Mean±SD)
Ad1	15.0±0	8.0±1.41	7.0±2.82	4.5±0.70
Ad2	17.0±0	7.0±1.41	6.5±0.70	4.5±2.12
Ad3	16.0±0	8.5±2.12	5.5±2.12	4.0±2.82
Ad4	19.0±0	8.0±4.24	6.5±2.12	5.0±1.41
Ad5	18.0±0	9.0±1.41	4.5±2.12	4.5±3.53
Ad6	21.0±0	6.5±0.70	5.5±2.12	3.5±2.12
Ad7	21.0±0	8.0±1.41	5.5±3.53	5.5±3.53
Ad8	15.0±0	8.0±2.82	5.5±4.94	4.5±3.53
Ad9	17.0±0	6.0±2.82	5.5±0.70	5.5±2.12
Ad10	22.0±0	6.5±2.12	6.5±0.70	4.5±0.70

Table 4. Comparison of Adhesive force (N) between different groups of DA+MN using Turkey-Kramer multiple comparison test

Comparison	Mean Difference	q¥	P-value
Group A Vs Group B	10.550	22.954	***P< .001******
Group A Vs Group C	12.250	26.652	***P< .001******
Group A Vs Group D	13.500	29.372	***P< .001******
Group B Vs Group C	1.700	3.699	*P> .05 NS*
Group B Vs Group D	2.950	6.418	***P< .001******
Group C Vs Group D	1.250	2.720	*P> .05 NS*

*Note: ¥If the value of q is greater than 3.813 then P value is less than .05; ***= highly significant; NS = Not significant.*

Since post-prosthesis care is often overlooked during the manufacture of removable dentures, it has been recommended that patient instructions on the usage of adjunctive devices such as denture adhesives should be included in post-placement care [34]. The preparation and usage of two agents were chosen for this study: denture adhesive paste and MN antifungal agent. In this study, we have attempted incorporating various formulations and concentration of MN-micro particles on DA to achieve efficient antifungal activity, without impairment on adhesive force.

The current research demonstrates the comparison of various Miconazole nitrate concentrations using the one way ANOVA test. The test result indicates that there was a substantial increase in antimicrobial activity after the addition of Miconazole nitrate and that the activity rises when the concentration of MN is increased that is highly significant. The results of present study are in accordance with results reported by previous study [33] for MN in gel form.

The tukey-kramer multiple comparison test was used to compare various Miconazole nitrate concentrations for adhesive force measurement. The test result indicates that there was highly significant difference between the control and Miconazole nitrate 10%, 20%, and 30% groups. This indicates that the adhesive force was significantly reduced after the addition of Miconazole nitrate. The results of present study are in contradiction with results reported by previous study [33] for MN in gel form. It may be due to use of polymer particles in previous study, which increase viscosity of DA. In current study as the MN concentration increases, the adhesive forces decreased. It may be due to reduced viscosity of DA.

The zone of inhibition agar disc diffusion test was used to determine antimicrobial property in this research. This test has been developed as a fast, low-cost, and easy technique for predicting dental materials antifungal properties. Several researchers have been conducted to determine the antimicrobial potential of dental materials using this technique [34-36].

Candida albicans can potentially contribution to other morbidities e.g. Cancer [37-38], cardiac risk [1]. Potential *C. albicans* mechanisms of contributing to disease include potent induction of IL-17 signaling, breach of gut epithelial barriers and activation of multiple cancer-associated factors [39].

Although ISO 10873 recommends a standard test, several authors have evaluated the adhesive strength of DA [40-42], and mucoadhesive drug delivery systems using alternative techniques [42]. The test employed here, as suggested by Zhao et al. [34], has the benefit of being easy to administer and needing no specialized equipment. Acrylic resin cylinders are easy to produce and simple to place in the testing equipment. Nonetheless, this technique, like the one prescribed by ISO 10873, it does not take into account variables that may affect the findings, such as the presence of natural saliva, keratinized mucosa, and intaglio surface. Other limitations are: use of a single species of oral biofilm, qualitative analysis, not considered toxicity, and a single heat-polymerized denture foundation. Future study should be carried out with large sample size, qualitative analysis of mycology test, and considering toxicity of the intervention with oral environment simulation that will give more accurate results regarding antimicrobial efficacy without affecting adhesive force of DA.

5. CONCLUSION

Within the limitation of study, anti-microbial property of denture adhesive paste increases with the addition of Miconazole Nitrate. Qualitative anti-microbial property for favorable laboratory performance can be achieved only after the addition of 20% w/w Miconazole Nitrate to denture adhesive paste.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

CONSENT

Since the present study was in-vitro, so there was no need of patient consent.

ETHICAL APPROVAL

Ethical approval had been taken from institutional ethical committee before starting the study. (S.NO./MPMSU/ ACADEMIC/2016-17/112)

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Ribeiro AB, de Araújo CB, Silva LEV, Fazan-Junior R, Salgado HC, Ribeiro AB, Fortes CV, Bueno FL, de Oliveira VC, de F O Paranhos H, Watanabe E, da Silva-Lovato CH. Hygiene protocols for the treatment of denture-related stomatitis: local and systemic parameters analysis - a randomized, double-blind trial protocol. Trials. 2019;20(1):661.
   DOI: 10.1186/s13063-019-3854-x. PMID: 31783777; PMCID: PMC6884795.
2. Newton Av. Denture Sore Mouth. A Possible Etiology. Br Dent J. 1962;357–60.
3. Barbeau J, Séguin J, Goulet JP, de Koninck L, Avon SL, Lalonde B, Rompré P, Deslauriers N. Reassessing the presence of Candida albicans in denture-related stomatitis. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2003;95(1):51-9.
   DOI: 10.1067/moe.2003.44. PMID: 12539027.
4. Emami E, Taraf H, de Grandmont P, Gauthier G, de Koninck L, Lamarche C, de Souza RF. The association of denture stomatitis and partial removable dental prostheses: a systematic review. Int J Prosthodont. 2012;25(2):113-9.
   PMID: 22371829.
5. Webb BC, Thomas CJ, Willcox MD, Harty DW, Knox KW. Candida-associated denture stomatitis. Aetiology and management: a review. Part 2. Oral diseases caused by Candida species. Aust Dent J. 1998;43(3):160-6.
   DOI: 10.1111/j.1834-7819.1998.tb00157.x. PMID: 9707778.
6. Nikawa H, Jin C, Makihira S, Egusa H, Hamada T, Kumagai H. Biofilm formation of Candida albicans on the surfaces of deteriorated soft denture lining materials caused by denture cleansers in vitro. J Oral Rehabil. 2003;30(3):243-50.
   DOI: 10.1046/j.1365-2842.2003.01024.x. PMID: 12588495.
7. Shakya P, Jain D,Rahangdale T. Evaluation and Comparison of Effect of Delmopinol Application on Adherence of Candida albicans on Denture Fitting Surface on Three Types of Acrylic Resin: An in vitro Study. International Journal of Prosthodontics and Restorative Dentistry. 2012;2(4):129-135.
8. Gendreau L, Loewy ZG. Epidemiology and etiology of denture stomatitis. J Prosthodont. 2011;20(4):251-60.
   DOI: 10.1111/j.1532-849X.2011.00698.x. Epub 2011 Apr 4. PMID: 21463383.
9. Radford DR, Challacombe SJ, Walter JD. Denture plaque and adherence of Candida albicans to denture-base materials in vivo and in vitro. Crit Rev Oral Biol Med. 1999;10(1):99-116.
   DOI: 10.1177/10454411990100010501. PMID: 10759429.
10. Rodrigues JA, Höfling JF, Tavares FC, Duarte KM, Gonçalves RB, Azevedo RA. Evaluation of biochemical and serological methods to identify and clustering yeast cells of oral Candida species by CHROMagar test, SDS-PAGE and ELISA. Braz J Biol. 2004;64(2):317-26.
    DOI: 10.1590/s1519-69842004000200018. PMID: 15462306.
11. Sullivan DJ, Moran G, Donnelly S, Gee S, Pinjon E, McCartan B, Shanley DB, Coleman DC. Candida dubliniensis: An update. Rev Iberoam Micol. 1999;16(2):72-6.
    PMID: 18473572.
12. Gutiérrez J, Morales P, González MA, Quindós G. Candida dubliniensis, a new fungal pathogen. J Basic Microbiol. 2002;42(3):207-27.
    DOI: 10.1002/1521-4028(200206)42:3<207::AID-JOBM207>3.0.CO;2-C. PMID: 12111748.
13. Jabra-Rizk MA, Baqui AA, Kelley JI, Falkler WA Jr, Merz WG, Meiller TF. Identification of Candida dubliniensis in a prospective study of patients in the United States. J Clin Microbiol. 1999;37(2):321-6.
    DOI: 10.1128/JCM.37.2.321-326.1999. PMID: 9889211; PMCID: PMC84296.
14. Minagi S, Miyake Y, Inagaki K, Tsuru H, Suginaka H. Hydrophobic interaction in Candida albicans and Candida tropicalis adherence to various denture base resin materials. Infect Immun. 1985;47(1):11-4.
    DOI: 10.1128/iai.47.1.11-14.1985. PMID: 3880719; PMCID: PMC261449.

15. McCourtie J, Douglas LJ. Relationship between cell surface composition of Candida albicans and adherence to acrylic after growth on different carbon sources. Infect Immun. 1981;32(3):1234-41.
DOI: 10.1128/iai.32.3.1234-1241.1981. PMID: 7019091; PMCID: PMC351584.
16. Rai VK, Yadav NP, Sinha P, Mishra N, Luqman S, Dwivedi H, Kymonil KM, Saraf SA. Development of cellulosic polymer based gel of novel ternary mixture of miconazole nitrate for buccal delivery. Carbohydr Polym. 2014;103:126-33.
DOI: 10.1016/j.carbpol.2013.12.019. Epub 2013 Dec 14. PMID: 24528709.
17. Papadiochou S, Emmanouil I, Papadiochos I. Denture adhesives: a systematic review. J Prosthet Dent. 2015;113(5):391-397.e2.
DOI: 10.1016/j.prosdent.2014.11.001. Epub 2015 Mar 4. PMID: 25749085.
18. Han JM, Hong G, Hayashida K, Maeda T, Murata H, Sasaki K. Influence of composition on the adhesive strength and initial viscosity of denture adhesives. Dent Mater J. 2014;33(1):98-103.
DOI: 10.4012/dmj.2013-178. PMID: 24492119.
19. Bartels HA. Bacteriological appraisal of adhesive denture powders. J Dent Res. 1945; 24:15–6.
20. Shaikh R, Raj Singh TR, Garland MJ, Woolfson AD, Donnelly RF. Mucoadhesive drug delivery systems. J Pharm Bioallied Sci. 2011;3(1):89-100.
DOI: 10.4103/0975-7406.76478. PMID: 21430958; PMCID: PMC3053525.
21. Cardot JM, Chaumont C, Dubray C, Costantini D, Aiache JM. Comparison of the pharmacokinetics of miconazole after administration via a bioadhesive slow release tablet and an oral gel to healthy male and female subjects. Br J Clin Pharmacol. 2004;58(4):345-51.
DOI: 10.1111/j.1365-2125.2004.02154.x. PMID: 15373926; PMCID: PMC1884608.
22. Nafee NA, Ismail FA, Boraie NA, Mortada LM. Mucoadhesive buccal patches of miconazole nitrate: *In vitro/In vivo* performance and effect of ageing. Int J Pharm. 2003 Oct 2;264(1-2):1-14.
DOI: 10.1016/s0378-5173(03)00371-5. PMID: 12972331.
23. Leite AR, Mendoza-Marin DO, Paleari AG, Rodriguez LS, Roccia AA, Policastro VB, Compagnoni MA, de Souza RF, Pero AC. Crossover clinical trial of the influence of the use of adhesive on biofilm formation. J Prosthet Dent. 2014;112(2):349-56.
DOI: 10.1016/j.prosdent.2013.11.003. Epub 2014 Feb 14. PMID: 24529654.
24. Vazquez JA, Sobel JD. Miconazole mucoadhesive tablets: a novel delivery system. Clin Infect Dis. 2012;54(10):1480-4.
DOI: 10.1093/cid/cis205. Epub 2012 Apr 10. PMID: 22495075.
25. Sawyer PR, Brogden RN, Pinder RM, Speight TM, Avery GS. Miconazole: a review of its antifungal activity and therapeutic efficacy. Drugs. 1975;9(6):406-23.
DOI: 10.2165/00003495-197509060-00002. PMID: 1149649.
26. Rindum JL, Holmstrup P, Pedersen M, Rassing MR, Stoltze K. Miconazole chewing gum for treatment of chronic oral candidosis. Scand J Dent Res. 1993;101(6):386-90.
DOI: 10.1111/j.1600-0722.1993.tb01137.x. PMID: 8290882.
27. Rassol BKA, Khan SA. In vitro evaluation of miconazole Mucoadhesive buccal films. Int J Appl Pharm 2010; 2:23–6.
28. Bouckaert S, Schautteet H, Lefebvre RA, Remon JP, van Clooster R. Comparison of salivary miconazole concentrations after administration of a bioadhesive slow-release buccal tablet and an oral gel. Eur J Clin Pharmacol. 1992;43(2):137-40.
DOI: 10.1007/BF01740659. PMID: 1425869.
29. Bouckaert S, Remon JP. In-vitro bioadhesion of a buccal, miconazole slow-release tablet. J Pharm Pharmacol. 1993;45(6):504-7.
DOI: 10.1111/j.2042-7158.1993.tb05588.x. PMID: 8103096.
30. Gupta A, Garg S, Khar RK. Measurement of bio adhesive strength of Mucoadhesive buccal tablets: design of an in vitro assembly. Indian Drugs 1993;30:152–5.
31. Cartagena AF, Esmerino LA, Polak-Junior R, Olivieri Parreiras S, Domingos Michél M, Farago PV, Campanha NH. New denture adhesive containing miconazole nitrate polymeric microparticles: Antifungal, adhesive force and toxicity properties. Dent Mater. 2017;33(2):e53-e61.
DOI: 10.1016/j.dental.2016.09.039. Epub 2016 Oct 10. PMID: 27745775.
32. Zhao K, Cheng XR, Chao YL, Li ZA, Han GL. Laboratory evaluation of a new

denture adhesive. Dent Mater. 2004;20(5): 419-24.
DOI: 10.1016/j.dental.2002.12.001. PMID: 15081547.
33. Pelka M, Danzl C, Distler W, Petschelt A. A new screening test for toxicity testing of dental materials. J Dent. 2000;28(5):341-5.
DOI: 10.1016/s0300-5712(00)00007-5. PMID: 10785300.
34. Milhem MM, Al-Hiyasat AS, Darmani H. Toxicity testing of restorative dental materials using brine shrimp larvae (Artemia salina). J Appl Oral Sci. 2008;16(4):297-301.
DOI: 10.1590/s1678-77572008000400013. PMID: 19089264; PMCID: PMC4327541.
35. ISO 10873. Dentistry-denture adhesives. Geneva: International Organization for Standardization; 2010.
36. DeVengencie J, Ng MC, Ford P, Iacopino AM. In vitro evaluation of denture adhesives: possible efficacy of complex carbohydrates. Int J Prosthodont. 1997;10(1):61-72.
PMID: 9484072.
37. Koppang R, Berg E, Dahm S, Real C, Fløystrand F. A method for testing denture adhesives. J Prosthet Dent. 1995;73(5):486-91.
DOI: 10.1016/s0022-3913(05)80080-0. PMID: 7658401.
38. Chinna Reddy P, Chaitanya KS, Madhusudan Rao Y. A review on bioadhesive buccal drug delivery systems: current status of formulation and evaluation methods. Daru. 2011;19(6):385-403.
PMID: 23008684; PMCID: PMC3436075.
39. Vargas KG, Joly S. Carriage frequency, intensity of carriage, and strains of oral yeast species vary in the progression to oral candidiasis in human immunodeficiency virus-positive individuals. J Clin Microbiol. 2002;40(2):341-50.
DOI: 10.1128/JCM.40.2.341-350.2002. PMID: 11825940; PMCID: PMC153371.
40. Han JM, Hong G, Dilinuer M, Lin H, Zheng G, Wang XZ, Sasaki K. The adhesive strength and initial viscosity of denture adhesives. Acta Odontol Scand. 2014;72(8):839-45.
DOI: 10.3109/00016357.2014.913309. Epub 2014 May 5. PMID: 24791610.
41. Ho J, Camilli G, Griffiths JS, Richardson JP, Kichik N, Naglik JR. Candida albicans and candidalysin in inflammatory disorders and cancer. Immunology. 2021;162(1):11-16.
DOI: 10.1111/imm.13255. Epub 2020 Sep 13. PMID: 32880925; PMCID: PMC7730014.
42. Yangyang SHI, Xuedong Z, Lei C, Biao. REN. The relationship between Candida albicans infection and oral cancer. Journal of Prevention and Treatment for Stomatological Diseases. 2021;(12):119–23.

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