ISSN: 2582-9904

ORIGINAL RESEARCH

Evaluation of the Surface Characteristics of Irreversible Hydrocolloid Impression Material incorporated with Silver Nanoparticles at Different Concentrations- An Invitro Study

Vidyalakshmi SP,[a] Prabhu R,[b] Rathika Rai [c]

ABSTRACT

Background: Incorporation of Silver nano-particles in irreversible hydrocolloid impression materials to improve the antimicrobial property, could influence the surface characteristics of the impression material.

Aim: To evaluate the surface roughness and surface detail reproduction of irreversible hydrocolloid impression material incorporated with silver nano-particles at different concentrations.

Materials and Methods: A total of 80 samples were selected and were grouped randomly into four groups of 20 samples each. The Group I (C.G), Group II (T.G 1) Group III (T.G 2) & Group IV (T.G 3) samples were casts poured from irreversible hydrocolloid impression material without AgNp, with 1% of AgNp, 1.5% of AgNp& with 2% concentration of AgNp respectively. The samples were employed for evaluating the surface detail reproduction and Surface Roughness.Chi square test and Kruskal wallis testwere used to analyze the surface texture statistically both within and between the test groups.

Results: The surface detail reproduction was satisfactory with all the four groups. Statistically significant changes was observed in Groups IV test sample and a statistically insignificant surface change was observed in Groups I ,II and III test samples. There was a negligible change in surface roughness in Groups I, II, and III test samples with a slight increase in surface roughness in Group IV samples.

Conclusion: All the test groups produced satisfactory surface detail reproduction on irreversible hydrocolloid impressions. 2% AgNp group alone have resulted in statistically significant changes in surface detail reproduction. All the test samples except 2% AgNp group showed increase in surface roughness values. (AgNp- silver nanoparticles, T.G-Test group, C.G –Control group)

Keywords: *irreversible hydrocolloid impressions, silver nanoparticle, surface characteristics*.

INTRODUCTION

Impression is said to be the negative likeliness or copy in reverse of the surface of an object. Usually it is made by placing a soft, semi fluid material in the mouth and allowing the material to set. Dental impression materials can be broadly classified as rigid and elastic impression materials. Among them, the Elastic hydrocolloid impression materials, such as the reversible (Agar-Agar) and irreversible (Alginate) hydrocolloids were the first elastic materials to be used in the dental field.

Irreversible hydrocolloid impression material forms an inseparable part of indirect restorations since 1950s and is used in dentistry for the past 60 years [1]. This isbecause these impression materials posses several advantages like low cost, ease of handling, short execution time, and the possibility of recording a detailed impression (even in the presence of undercuts) . Apart from dental

[a] Postgraduate, Department of Prosthodontics, Thai Moogambigai Dental College, Chennai.
[b] Professor, Department of Prosthodontics, Madha Dental College, Chennai
[c] Principal and Head, Department of Prosthodontics, Thai Moogambigai Dental College, Chennai.

impressions, alginate impression materials were also used in medical field in replicating the maxillofacial regions and also in orthopaedic purposes [2].

The presence of viable microorganisms and fungi have been reported in the containers of alginate powder while storage. These colonies of micro organisms pose a potential source of infection during impression making in patients with pre-existing ulcers, lacerations and any soft tissue trauma. Thus there is a risk of accidental transmission of this infectious substrate to undesired sites in the oral cavity. Hence, the addition of antimicrobial agents into irreversible hydrocolloid impression materials prior to impression making seems to be pertinent[3].

The development of nanotechnology led to the promising results in antibacterial therapies because of their enhanced and unique biochemical properties . Nanoparticles usually refer to tiny solid particles with a diameter of 1–100 nm[4].

Silver had a long history of being used as a broad-spectrum antimicrobial agent and is used in the treatment of skin ulcers, burn injuries, and eye infections[5.] This has led to the incorporation of silver nanoparticles (AgNps) in various dental materials like denture base resins, tissue conditioners and reliners for their antimicrobial property[6]. Recent study has show that silver nanoparticles can be incorporated in to irreversible hydrocolloid impression material to improve its antimicrobial activity [7]. Apart from antimicrobicial property , an ideal impression material should possess surface characteristic like roughness free surface and accurate surface detail reproduction for achieving fit and dimensional accuracy of the prosthesis. But there are no sufficient invitro/in vivo studies to prove that the incorporation of silver nanoparticles in irreversible hydrocolloid impression materials could have any influence on the surface characteristics of these impression materials.

Figure 1: stainless steel master die –metal base with `detachable cylindrical ring

Hence this invitro study was aimed to evaluate the surface characteristics of irreversible hydrocolloid impression material incorporated with silver nanoparticles at different concentrations.The null hypothesis for the present study was that no significant changes would be observed with respect to surface detail reproduction and surface texture following the addition of silver nanoparticles in irreversible hydrocolloid impression material.

MATERIALS AND METHODS:

A Power analysis was done to evaluate the sample size. With 85 % power, margin of error at 5% and 95% confidence level, the estimated sample size was 76. For convenience of group distribution, a total of 80 samples were selected. A stainless-steel master die was constructed according to American National Standards Institute/American Dental Association (ANSI/ADA) specification No. 18 for alginate impression materials. Three vertical lines of 25 mm length and of 25 µm, 50 µm and 75 µm width were engraved on the metal surface of the stainless steel block. (Figure 1) Irreversible hydrocolloid powder (Zelgan Plus, DENTSPLY, India) each weighing 100gm were dispensed into a container. The samples consisted of 5g of alginate powder without addition of silver nanoparticles, which served as the control and with addition of 1%,1.5% & 2% concentration of silver nanoparticles ,serving as the test group .They were prepared by mixing thepowder with 5ml of deionized water. The alginate powder was wetted manually for 15 seconds, followed by mechanical mixing for 30 seconds to get homogeneous mix. The mixed material was placed on the center of the stainless steel block surface after the placement of the ring within 1 minute from the start of mixing. A glass plate was placed on ring surface with sufficient force to seat the plate firmly against the stainless-steel ring. The glass plate was then loaded with 1 kg weight on top of it. About 3 minutes after the minimum setting time recommended by the manufacturer, the stainless-steel ring was separated along with the impression from the stainless-steel block surface. Therefore, the separation time was approximately 5 minutes from the start of mixing.

Pouring of gypsum cast: If the impressions passed ANSI/ADA specification, they were cast in type IV die stone. Die stone (Ultrarock, Kalabhai Karlson Pvt ltd, Mumbai.) was mixed as recommended by the manufacturer under vacuum. The vacuum mixed die stone was poured against the treated impression surface by using vibrator,such that it reproduced the entire length of the vertical lines. The poured impression was then stored at room temperature for an hour, after which it was separated from the cast. After retrieval of the casts, the specimens were numbered for identification. The specimens were allowed to dry for a minimum of 24 hours before evaluation of detail reproduction. Hence a total of 80 specimens (stone casts) were poured from the irreversible hydrocolloid impressions. (Figure 2)

The 80 test samples were grouped into four groups of 20 samples each based on the concentration of silver nanoparticles. The 20 samples from each test group were employed for evaluating the surface detail reproduction and Surface Roughness. Of these:

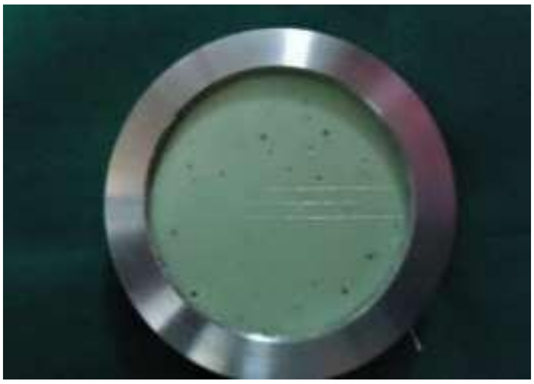


Figure 2: Irreversible hydrocolloid impression material made in the master die

- Group I (C.G) samples were casts poured from irreversible hydrocolloid impression material without silver nanoparticles.
- Group II (T.G 1) samples were casts poured from irreversible hydrocolloid impression material with 1% concentration of silver nanoparticles.
- Group III (T.G 2) samples were casts poured from irreversible hydrocolloid impression material with 1.5% concentration of silver nanoparticles.
- Group IV (T.G 3) samples were casts poured from irreversible hydrocolloid impression material with 2% concentration of silver nanoparticles.

Evaluation of surface roughness on test samples:
All stone casts were subjected to profilometric tracing using a Surface Roughness tester (3D software - Taylor Hobson, Ametek, India.) consisting of a noncontact profilometer with a lens covering of range 2.5 µm. The surface roughness of each test sample was measured at three points (X, Y and Z). Of these, the first point has been randomly selected and the other two points were at a distance of 5 mm from the first one. The surface texture tracings were performed at a speed of 20µm/s. The average surface roughness (Ra) values were obtained in micrometre (µm) and the 3D surface profile images were also obtained for each test sample and recorded for all the four groups. (Figure 3)

Evaluation of surface detail reproduction on test samples:

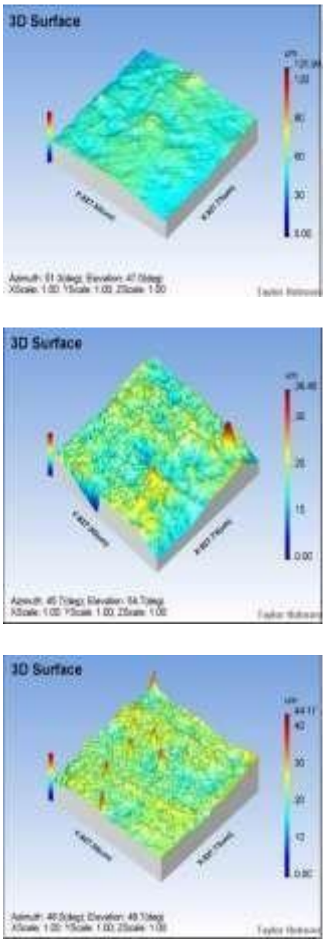


Figure 3: 3d surface roughness image in (a)control group ,(b)t.g.2 (c) t.g.3. Note the peaks and valleys (red) which are evident in 2% group

According to ANSI/ADA specification No. 18, dental stone casts made from irreversible hydrocolloid impression , specimens have to reproduce the 75 µm wide line (engraved in the stainless steel die). For grading purposes both the 75 µm and 50 µm wide lines were analysed for irreversible hydrocolloid specimens.

All stone specimens were examined under low angle illumination at 30x magnification with a stereomicroscope (Olympus corp, India.) to which a camera is connected. Images of the specimens were then assessed for surface detail reproduction. (Figure 4)

For better discrimination between specimens, a scoring system with rating values from 1 to 4 was followed:

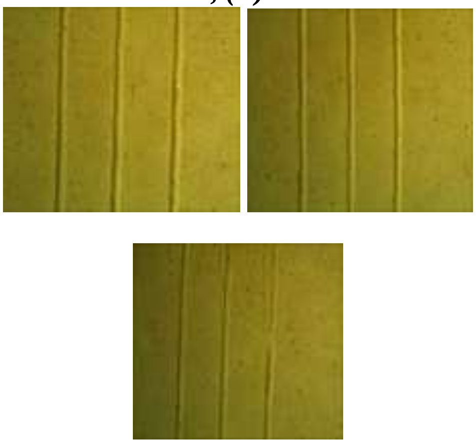
- Grade 1 – Well-defined, sharp detail, continuous line
- Grade 2 - Continuous line but with some loss of sharpness

- Grade 3 - Loss of continuity of the line or significant loss of detail
- Grade 4 - Failure to reproduce lines.

RESULTS:

All data were tabulated, statistically analysed with the Chi square test. The Kruskal Wallis test was used to compare among the groups.For evaluation of surface roughness, the data obtained from the profilometric traces of all the representative test samples of each group were tabulated and their mean was calculated. The mean was analyzed. The mean rank for surface roughness of group T.G.3 showed the highest value of 27.45 indicating the marked increase in surface roughness. (Table 1)

Figure 4: Stereomicroscopic images of surface detail reproduction (A)Grade 1,(B) Grade 2, (C)Grade 3



Groups	N	Mean (µm)	SD	P value
C.G (control group)	20	22.12	.1293	0.233
T.G 1 (1 %AgNp)	20	23.09	.1010	0.342
T.G 2 (1 .5 %AgNp)	20	25.56	.1715	0.441
T.G 3 (2 %AgNp)	20	27.45	.0972	0.021*

Table 1-Comparison of surface roughness values of irreversible hydrocolloid impression material incorporated with silver nanoparticles at different concentrations. * significant value.

DISCUSSION:

The origin of the cross contamination can start from the materials used during the manufacturing process i.e. the use of contaminated equipment, operator errors air entrapment, during packing, transportation, and even by the dentist.[3] As to the latter, even if the impression materials were free of contamination at first, there can be likelihood of contamination because the material is kept in large packs. By transferring them to the container, microorganisms from the environment could be introduced into it, which would make these impression materials inappropriate for further use, from a microbiological aspect.

The chances of contaminating immune-compromised patients in dental procedures are of major concern since they are susceptible to infections by even microbes of low virulence. Seeing that it is impractical to assess the patients' immunological status during each dental procedure, there is a need for adopting the concept of using prefabricated impression materials with antimicrobial properties[8].

Recent study has shown that silver nanoparticles can be incorporated into irreversible hydrocolloid impression material to improve its antimicrobial activity[7]. But then, the incorporation of silver nanoparticles in irreversible hydrocolloid impression materials could have influence on the surface characteristics of these impression materials.

The null hypothesis that there is no difference with respect to surface detail reproduction and surface roughness by addition of silver nanoparticles in alginate impression material was rejected.

For the measurement of surface detail reproduction and surface texture, most studies have used the metallic dies standardized by American dental association. Hence, in the present study, a similar master die was fabricated in accordance with ADA Specification No. 18.

Antimicrobial action of AgNps depends on their size, distribution, shape, and surface chemistry. Smaller AgNps of 3nm size were more cytotoxic than larger particles (25 nm) at a concentration of 10 µg/mL[9]. For better efficiency, size, shape, and morphology of the nanoparticles are permanent. Hence in this study, to prevent the cytotoxic effects, we used the Silver nanoparticles at a size of 20nm which dissolute in distilled water.

Many irreversible hydrocolloid impression materials are available like chromatic alginates, fast set alginates and presently, Dustless irreversible hydrocolloids are used. Hence to avoid the contamination, a dust free Irreversible hydrocolloids was used in this present study to make all the 80 test impressions

The results of the surface detail reproduction of the present study is in line with the study by Shambhu et al[10] which showed satisfactory surface detail reproduction for the irreversible hydrocolloid impressions.

The established grading system was found to be reproducible and satisfactory. The findings of this study appear to agree with those of previous workers[11], with regard to the surface detail of casts from those impressions treated with chlorine-based disinfectants and disinfection with UV radiation.

Regarding surface roughness the results obtained in the present study are indicative of a favourable response, that is, hardly any changes were obtained except for 2% AgNp group where a mild increase in roughness is observed. The results are in line with the study by chang et al[12] , compared the surface roughness of six brands of alginate impression materials on their gypsum models .

In a study of Júnior *et al.*[13], there was a decrease of the area (in mm^2) of the type IV dental stone samples, which resulted in relevant mis adaptation of prostheses waxed onto these casts. However, there was no increase in superficial porosity without statistically significant differences in the superficial roughness values before and after disinfection.

Rentzia *et al.*[14], also verified an increase in Ra values after immersion of irreversible hydrocolloid in hypochlorite solution, but for the authors it is unclear whether the increased Ra values observed would have a clinically significant effect on the surface quality of the casts.

The roughness of all irreversible hydrocolloids tested reached values below those clinically acceptable, except for group 2 wt% AgNp. These high roughness values could have been influenced by the interaction between the alginate with the silvernanoparticles of the impressions . This agrees with the study by dorner et al [15].

However, further studies involving larger sample sizes are required before arriving at definite conclusions with respect to surface roughness.

CONCLUSION:

The following conclusions were drawn from the data obtained in this invitro study:

The surface roughness and surface reproduction values rendered with the addition of silver nanoparticles were inconsistent which proves that the varying concentrations of AgNp influenced the surface characteristics of the irreversible hydrocolloid impression materials.

The surface roughness values of 1% and 1.5% concentration of AgNp incorporated in irreversible hydrocolloid impression material did not have any statistically significant changes except 2 % AgNp group, which showed slight increase in surface roughness values.

The surface detail reproduction values of of 1% and 1.5% concentration of AgNp incorporated in irreversible hydrocolloid impression material did not have any changes and seldom failed to reproduce the details within the limitations.

Acknowledgements:CG-FIST, Manufacturing engineering section, Anna University, Chennai.

Conflict of Interest: Nil

REFERENCES

1. Doubleday B. Impression Materials. British Journal of Orthodontics. 1998 May;25(2):133-40.
2. Vogel AB, Kilic F, Schmidt F, Rübel S, Lapatki BG. Dimensional Accuracy of Jaw Scans Performed on Alginate Impressions or Stone Models. Journal of Orofacial Orthopedics/Fortschritte Kieferorthopädie. 2015 Jul 1;76(4):351-65.
3. Casemiro LA, Martins CH, Souza FD, Panzeri H, Ito IY. Bacterial, Fungal and Yeast Contamination in Six Brands of

Irreversible Hydrocolloid Impression Materials. Brazilian Oral Research. 2007 Jun;21(2):106-11.

4. Chaloupka K, Malam Y, Seifalian AM. Nanosilver as a New Generation of Nanoproduct in Biomedical Applications. Trends in Biotechnology. 2010 Nov 1;28(11):580-8.
5. Knetsch ML, Koole LH. New Strategies in the Development of Antimicrobial Coatings: The Example of Increasing Usage of Silver and Silver Nanoparticles. Polymers. 2011 Mar;3(1):340-66.
6. Jadhav R, Bhide S, Prasad BV, Shimpi J. Applications of Silver Nanoparticles in Prosthodontics: An Overview. European Journal of Prosthodontics. 2016 Sep 1;4(3):45-.
7. Ginjupalli K, Alla RK, Tellapragada C, Gupta L, Perampalli NU. Antimicrobial Activity and Properties of Irreversible Hydrocolloid Impression Materials Incorporated with Silver Nanoparticles. The Journal of Prosthetic Dentistry. 2016 Jun 1;115(6):722-8.
8. Cottone JA, Terezhalmy GT, Molinari JA. Practical Infection Control in Dentistry. Lea & Febiger; 1991.
9. Sawai J, Yoshikawa T. Quantitative Evaluation Of Antifungal Activity Of Metallic Oxide Powders (MgO, CaO and ZnO) by an Indirect Conductimetric Assay. Journal Of Applied Microbiology. 2004 Apr;96(4):803-9.
10. Shambhu HS, Gujjari AK. A Study on the Effect on Surface Detail Reproduction of Alginate Impressions Disinfected with Sodium Hypochlorite and Ultraviolet Light—An In Vitro study. The Journal of Indian Prosthodontic Society. 2010 Mar 1;10(1):41-7.
11. Schwartz RS, Hensley DH, Bradley Jr DV. Immersion Disinfection of Irreversible Hydrocolloid Impressions in pH-Adjusted Sodium Hypochlorite. Part 1: Microbiology. International Journal of Prosthodontics. 1996 May 1;9(3).
12. Chang YC, Yu CH, Liang WM, Tu MG, Chen SY. Comparison of the Surface Roughness of Gypsum Models Constructed Using Various Impression Materials and Gypsum Products. Journal of Dental Sciences. 2016 Mar 1;11(1):23-8.
13. Júnior GC, Bastos LG, Ferreira PM, Rubom JH. Evaluation of Physico-Mechanical Properties of a Type IV Gypsum Subjected to Disinfection Methods. Part II - Superficial Roughness and Dimensional Stability. C OdontolBrasileira2003;6:31-5.

Corresponding author:

Dr. S.P Vidyalakshmi,

Postgraduate, Department of Prosthodontics and Crown & Bridge,

Thai Moogambigai Dental College, Chennai.

Contact No:+919840339386

Email: vidyasenthur@gmail.com.