Effects of disinfection procedures on surface quality of compound impressions and the resultant gypsum casts

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Abstract

Objective: To evaluate the effects of disinfection procedures on the detail reproduction of type I impression compound and the surface quality of the gypsum casts poured against the disinfected impressions.

Materials and methods: To make the specimens for detail reproduction test, thirty-five compound impressions of a brass test block (ADA Specification no. 3) were made. These impressions were divided into 7 groups. Five impressions were randomly chosen for each of the disinfectant-method combinations and control groups. For the six experimental groups, impressions were disinfected using either spraying with or immersion in 2.4% glutaraldehyde (Cidex), or 1: 213 iodophor (IodoFive) or 0.525% sodium hypochlorite (Hi-chlor). Five non-disinfected impressions served as controls. Each impression was visually evaluated for detail reproduction before and after disinfection and then poured with Type III dental stone. The resultant stone casts were evaluated for detail reproduction. To assess the surface roughness of the stone specimens, another thirty-five compound impressions of a glass slide were made and five impressions were randomly chosen to subject to each disinfection protocol as described in the detail reproduction test. All impressions were poured with dental stone. The surface roughness of the casts was recorded using a profilometer. The average surface roughness was compared using Tukey HSD test at 95% confidence interval.

Results: The surfaces of compound impressions did not deteriorate after disinfection with Cidex or IodoFive but deterioration was noted after spraying with or immersion in Hi-chlor. The stone casts obtained from Cidex and IodoFive groups showed smooth surfaces and continuous fine lines while degradation of the casts occurred when compound impressions were subjected to Hi-chlor. The average surface roughness of the casts obtained from Hi-chlor spray and immersion were significantly different from each other and from the remaining groups ($p<0.05$).

Conclusion: Cidex and IodoFive using as spray or immersion disinfection did not deteriorate the surfaces of compound impressions and the stone casts. Loss of surface detail and surface porosity could be observed after disinfection with Hi-chlor.

Key words: detail reproduction, immersion disinfection, impression compound, spray disinfection, stone cast, surface roughness

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Introduction

Dentists, assistants, dental technicians and laboratory personnel are exposed to infectious diseases from patients' saliva or blood via droplets and aerosols, or by direct contact.[1] Impressions taken from patients' mouths are also significant sources of cross-contamination.[2] Rinsing the impressions in running water is a method of gross decontamination and can remove only 40-90% of bacteria.[3] Leung and Schonfeld[4] found that oral pathogens could be transmitted subsequently from impressions to gypsum casts. Therefore, dental personnel have a higher risk of infectious diseases, such as hepatitis B virus (HBV), human immunodeficiency virus (HIV), herpes simplex viruses (HSV), tubercle bacillus, and viruses infesting the upper respiratory tract, than other people.[5, 6]

Guidelines set by the American Dental Association (ADA) and the Centers for Disease Control (CDC) suggest that all surfaces that have been splashed or touched by human body fluids be disinfected with a hospital-grade disinfectant registered with the Environmental Protection Agency.[7, 8] Therefore, impressions must be disinfected using an adequate level of disinfection in a short period of time to minimize distortion and deterioration of the surface quality of the impression and the resultant stone cast.[9]

Though irreversible hydrocolloids and elastomeric impression materials are currently the most popular dental impression materials in everyday practice, impression compound is still used for border molding and recording flat mandibular ridge for removable prostheses.[10-13] Impression compounds are thermoplastic materials; they soften when heated and harden on cooling to mouth or room temperature. Although several investigations have been conducted on the effects of disinfecting irreversible hydrocolloids and elastomeric impression materials,[14-19] impression compound has received little attention.[18] According to Anderson[10], impression compounds cannot be sterilized by chemical agents and suggested that heat sterilization in an autoclave for 10 minutes at 0.1 N/mm^2 (15 psi) should be performed. However, this method is not appropriate for impressions. Recently, disinfection of impression compound using 2% glutaraldehyde solution or iodophors or chlorine compounds has been recommended.[20] However, there is no experiment to support this recommendation.

It is apparent that controversy exists in the literature and the disinfection protocol for impression compound has not been clarified. This study evaluated the effects of three disinfectants (glutaraldehyde, iodophors and sodium hypochlorite) when used as spray and immersion disinfection on the detail reproduction properties of Type I impression compound and the surface quality (detail reproduction and surface roughness) of the resultant gypsum casts.

Materials and methods

Test for detail reproduction of compound impressions and stone casts

A brass test block machined to a complex surface of small pyramids, large grooves (grooves B – each groove was 4 mm wide) and fine parallel grooves (grooves C – each groove was 0.2 mm wide) as described in the detail reproduction test in ADA Specification no. 3 for impression compound[21] was used in this study (Fig.1).

Impression specimens were fabricated by placing the impression compound cake (Kerr Corp. Romulus, Michigan, U.S.A.), 40 mm in diameter, in the water bath adjusted to 45 ± 0.1°C. A flat glass plate used to support the specimen, a test block, and a brass weight of 1,000 ± 5 gm were placed in the water bath and allowed to settle to the temperature of

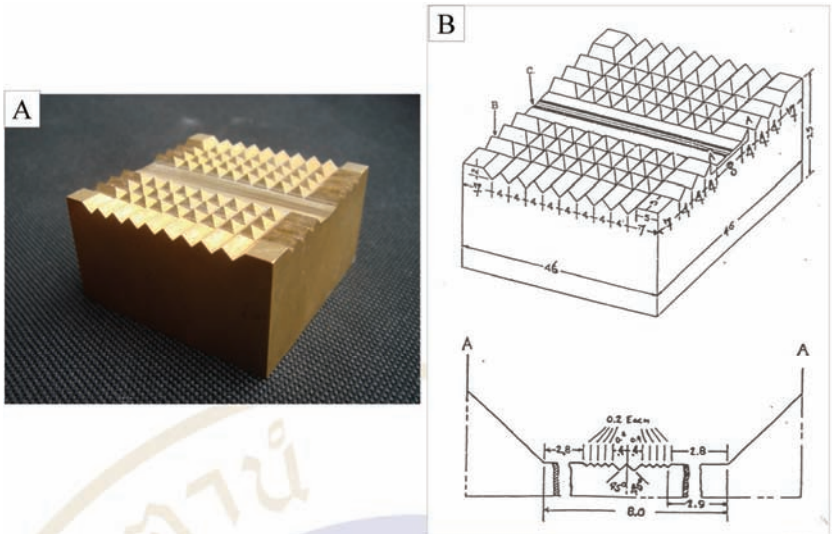

Fig. 1 (A) Brass test block as described in ADA Specification no. 3 for impression compound. (B) Diagrammatic representation of test block shown in (A).

the water bath. While this assembly remained in the water bath, the compound specimen was centered on the test block. A sheet of cellophane was placed over the compound specimen, and the weight was placed on the specimen for 10 minutes. After removal of the weight, the test block and the specimen were removed from the bath and cooled with distilled water at 10°C. The specimen was removed from the test block. Excess water on the impression surface was removed gently with an air syringe and the compound impression was immediately examined without magnification visually. To be acceptable for the control group and for the disinfection procedures, the impression had to completely reproduce the ridges of large grooves (grooves B, Fig.1) of the test block and the ridges of fine grooves (grooves C, Fig.1) had to be visible without magnification for at least 30 mm.[21] A total of thirty-five compound impressions were made, which were divided into 7 groups. Five impressions were randomly chosen for each of the disinfectant–method combinations and control groups. The controls were stored at room temperature (23 ± 2° C) for 10 minutes while the test impressions were randomly subjected to one of the disinfection protocols at room temperature for 10 minutes. Three disinfectants including 2.4% glutaraldehyde (Cidex – Johnson & Johnson Medical Limited, Gargrave, Skipton, U.K.), 1:213 iodophor (IodoFive - Cottrell Ltd. Denver, U.S.A.) and 0.525% sodium hypochlorite (Hi-chlor - Thasco Chemical Co.Ltd. Bangkok, Thailand) were selected. They all meet the requirement for tuberculocidal activity in 10 minutes.[5] The test protocol is presented in Table 1.

The impression in the spray group was sprayed with one of the test disinfectants in a "zip-lock" plastic bag, which was then sealed and stored at room temperature for 10 minutes. The impression in the immersion group was immersed in 200 mL of one of the test disinfectants for 10 minutes. After disinfection, the impression was rinsed for 30 seconds with room temperature distilled water and air-dried. Fresh disinfectant was used for each impression.

The disinfected impression was inspected again for sharpness of the surface details. The impression that met the criteria was recorded as "accepted". Changes in the impression surface were observed and noted. The disinfected impressions and the controls were

Table 1 Test protocol

Group	Disinfectant	Method	Contact time (minutes)	Sample size
I	Control (Non-disinfected)	-	-	5
II	Cidex	spray	10	5
III	Cidex	immersion	10	5
IV	IodoFive	spray	10	5
V	IodoFive	immersion	10	5
VI	Hi-Chlor	spray	10	5
VII	Hi-Chlor	immersion	10	5

then poured with Type III dental stone (Comet 3, Lafarge Prestia, France) under vibration (Vibrator model Mini export, Dentalfarm S.N.C. Torino, Italy). After 45 minutes the impression was separated from the cast by placing it in a small amount of water at 60-70°C and the impression was removed vertically. The corresponding large grooves and the fine grooves on the stone cast were visually inspected without magnification using the same criteria as described for the impression compound.

Test for surface roughness of stone casts

The methods of preparation of impression compound sample, disinfection of impression, and gypsum cast preparation were made in a similar way for detail reproduction test, with the exception that a glass slide (25 mm x 75 mm) was used as a master model instead of a brass test block. Two reference points 6 mm apart were marked on the glass slide and were duplicated onto the compound impressions and stone casts (Fig.2). Five impression compound samples were made for each of the disinfectant-method combinations and the control groups. Therefore, a total of 35 compound impressions were made and 35 dental stone specimens were obtained.

Surface roughness of the stone specimens was assessed by recording the surface profile using a profilometer (Talysurf serie 2, Tylor-Hobson Ltd., Leicester, England). The roughness average (R_a) values were measured from the two reference points and the mean of the two readings was used in the data analysis. The test conditions were set as follows: cut-off length = 0.25 mm, drive speed = 0.5 mm/second ± 5%, sample length = 3 mm. A 100 mg diamond stylus was used to determine the average roughness.

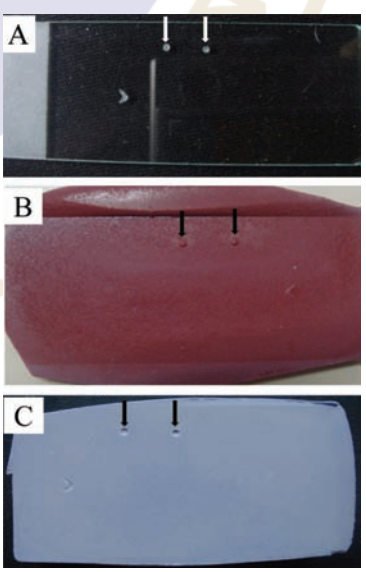

Fig. 2 (A) Glass slide with two reference points 6 mm apart (arrows) (B) Compound impression of the glass slide (C) Dental stone specimen for surface roughness test.

Surface roughness data was analyzed with one-way analysis of variance (ANOVA). The null hypothesis tested was that the roughness of the stone cast surface was not affected by disinfection procedures (disinfectant and method) of the compound impression. When the effects were significant and the null hypothesis was rejected, post hoc comparison was estimated using Tukey HSD test to identify which means differed. The hypothesis testing was conducted at the 5% significant level (α = 0.05).

Results

Detail reproduction of compound impressions and stone casts

All impression compound specimens before subjected to disinfection and the controls passed the criteria for detail reproduction (Fig.3).

Cidex and IodoFive did not have any deleterious effect on the surfaces of the impression compound using either spray or immersion disinfection methods (Fig.4 A-D). In addition, it was noted that IodoFive was the only disinfectant solution that stained the compound impression after immersion. After disinfection with Hi-chlor, all impression surfaces showed loss of well-defined, continuous ridges of fine grooves and surface porosity could be observed. (Fig.4 E, F). However, spraying with Hi-chlor did not deteriorate the impression to the same extent as immersion.

The stone casts in the control group demonstrated sharp large grooves and well defined, continuous lines of fine grooves for at least 30 mm and the stone cast surfaces were smooth (Fig.5), signifying that the impression compound was compatible with the dental stone (Comet 3).

The stone casts obtained from Cidex and IodoFive groups were the same as the controls (Fig.6 A-D). The casts subjected to disinfection with Hi-chlor spray and immersion exhibited loss of detail of the fine grooves (Fig.6 E, F). Chalky cast surface was observed only with Hi-chlor immersion.

Surface roughness of stone casts

Table 2 illustrates the average surface roughness (R_a) of the stone casts obtained from the control and disinfected impressions. Hi-chlor immersion produced the roughest cast surface, followed by Hi-chlor spray, Cidex immersion, IodoFive immersion, IodoFive spray, and Cidex spray. The control group produced the smoothest surface.

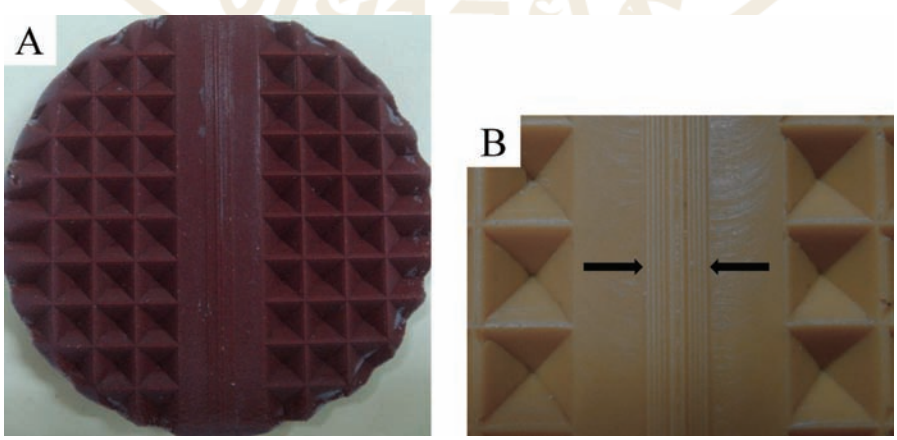

Fig. 3 (A) Impression compound specimen before subjected to disinfection. ; (B) Enlarged impression specimen (x 12 magnification) showing fine lines (arrows).

The differences among test groups were analyzed using one-way analysis of variance. The result showed that the disinfection procedure had a significant effect on the surface roughness of the stone casts ($p<0.05$). Post hoc comparison using Tukey HSD test indicated that the surface roughness of the stone casts in Hi-chlor spray and immersion groups were significantly different ($p<0.05$) and both groups were statistically different ($p<0.05$) from the remaining groups. Cidex and IodoFive using either spray or immersion method demonstrated no differences in roughness of the casts compared with the control group ($p> 0.05$). The groups prescribed with different superscript letters indicate statistical differences ($p<0.05$) as shown in Table 2.

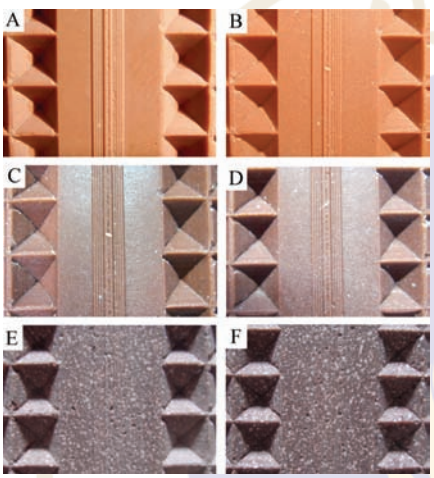

Fig. 4 Impression compound specimens (x 12 magnification): Sharp detail and continuous fine lines exhibited after Cidex spray (A), Cidex immersion (B), IodoFive spray (C) and IodoFive immersion (D). Loss of detail and surface porosity exhibited after Hi-chlor spray (E) and Hi-chlor immersion (F).

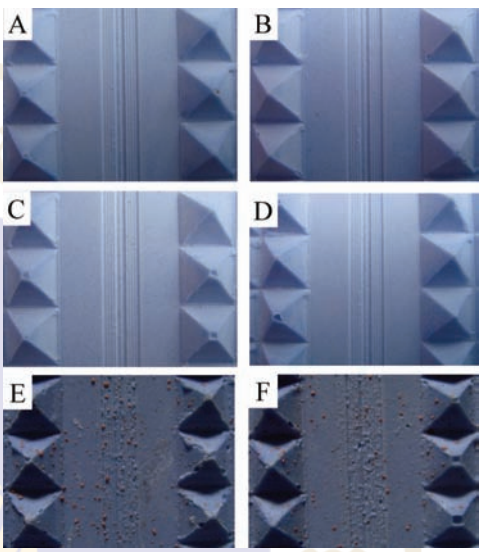

Fig. 6 Surfaces of the stone casts (x 12 magnification) obtained from disinfected compound impressions: Continuous fine lines and smooth cast surfaces were shown in Cidex spray (A), Cidex immersion (B), IodoFive spray (C) and IodoFive immersion (D). Blurring of fine lines was shown in Hi-chlor spray (E), and loss of fine lines and chalky cast surface were shown in Hi-chlor immersion (F).

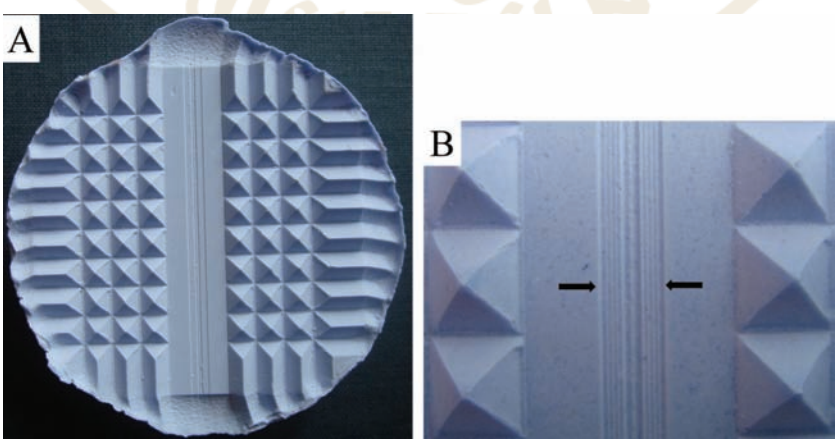

Fig. 5 (A) Surface of the stone cast obtained from the non-disinfected compound impression was smooth and the entire length of small lines was well defined. ; (B) Enlarged stone specimen (x 12 magnification) showing fine grooves (arrows).

Table 2 Average surface roughness, R_a, (μm) and standard deviation (SD) of dental stone casts poured against compound impressions (n= 5).

Group	Mean ± SD*
I Control (non-disinfected)	0.5395 ± 0.1091[a]
II Cidex (spray)	0.5925 ± 0.1653[a]
III Cidex (immersion)	0.6469 ± 0.1389[a]
IV IodoFive (spray)	0.6222 ± 0.0651[a]
V IodoFive (immersion)	0.6293 ± 0.0712[a]
VI Hi-chlor (spray)	1.1122 ± 0.0893[b]
VII Hi-chlor (immersion)	1.5483 ± 0.3647[c]

*Different superscript letters indicate statistical differences ($p<0.05$)

Discussion

In prosthodontic treatment, impression compound is not frequently used because its limited ability to record fine surface detail and impression compounds cannot be used when undercuts are present.[10] However, McCord and Tyson[13] described a heavy pressure impression technique using impression compound to record flat mandibular ridges of edentulous patients. These definitive impressions were completed without fluid-wash impression. Thus, the infection control protocol for impression compounds should be evaluated to protect dental personnel as well as minimize cross-contamination between patients. From a clinical standpoint, casts that accurately reproduce the fine details of oral structures contribute significantly to the success of the prosthesis. To provide a well fitting surface of finished prosthesis, disinfectants used for impression compound must be an effective antimicrobial agent and cause no adverse effects to surface features of the impression material and stone cast.

The ADA Specification no. 3 for dental impression compound does not mention the requirement of compatibility of impression compound with gypsum material. Since no information is available, this study expressed the results of detail reproduction of dental stone specimens using similar criteria as described for impression compound. Generally, if the impression compound does not record all grooves of the test block, the imperfect impression will result in a defective stone cast. Such defective stone cast is attained due to the technical errors in the impression technique and does not relate to the disinfection procedure. For this reason, the compound impressions that were accepted for the control group and for the disinfection procedures in this study had to pass the ADA criteria.

Regarding the disinfectants tested in this study, loss of surface detail of the impression surface was seen when the impression compound was subjected to sodium hypochlorite. The result is in agreement with the study by Storer and McCabe[18], which showed an extensive surface deterioration on the impression compound following immersion in 0.525% hypochlorite solution for 16 hours and caused oxidative degradation at the surface. No surface deterioration of the impression compound was noted after immersion in glutaraldehyde.

In this present study, IodoFive was the only disinfectant that stained the compound impression. Though the staining was light in intensity, it could be noticeable. This staining effect was also noted by Herrera and Merchant[22] when irreversible hydrocolloid impression materials were immersed in 1:213 iodophors for 10 minutes.

The results of this study showed no significant difference ($p>0.05$) in surface roughness of stone casts after disinfection with Cidex and IodoFive using either spray or immersion method. However, a recent review concluded that the efficacy of disinfection by immersion is preferred because spray disinfectant tends to pool and all impression surfaces may not be adequately covered. [23, 24]

Based on this study, the results suggest that when impression compound is indicated for partially or totally edentulous patients it may be disinfected with 2% glutaraldehyde or 1:213 iodophors using either spray or immersion method. However, in the future studies on dimensional stability and antimicrobial effectiveness need to be performed before their clinical usage. As these disinfectants can be hazardous to health, it is important that all members of the dental team should wear gloves and protected eyewear when handling disinfectants.

Within the limitations of this study, the following conclusions were drawn:

Compound impressions could be sprayed or immersed using 2.4% Cidex and 1:213 IodoFive for 10 minutes with no apparent negative effects on stone casts. There were no statistically significant differences in average surface roughness of the stone casts obtained from Cidex and IodoFive disinfection groups when compared with the control group ($p>0.05$).

0.525% Hi-chlor spray and immersion were not suitable for disinfecting impression compounds. The impression compound showed loss of details-sharpness and porosity of the impression surfaces. When impression was poured with dental stone, surface qualities of the stone casts were unacceptable. The casts exhibited loss of detail of the fine grooves. In addition, chalky surface of the casts appeared in the Hi-chlor immersion group. The average surface roughness of the stone casts obtained from Hi-chlor disinfected impressions was significantly different from the control group and the groups disinfected with Cidex and IodoFive ($p<0.05$).

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References

1. Center of Disease Control. Recommended infection-control practices for dentistry. In: Services DoHH, editor: ***U.S. Government Printing Office***; 1986.
2. Ho DD, Byington RE, Schooley RT, Flynn T, Rota TR, Hirsch MS. Infrequency of isolation of HTLV-III virus from saliva in AIDS. ***N Engl J Med*** 1985; 313: 1606.
3. Beyerle MP, Hensley DM, Bradley DV, Jr., Schwartz RS, Hilton TJ. Immersion disinfection of irreversible hydrocolloid impressions with sodium hypochlorite. Part I: Microbiology. ***Int J Prosthodont*** 1994; 7: 234-8.
4. Leung RL, Schonfeld SE. Gypsum casts as a potential source of microbial cross-contamination. ***J Prosthet Dent*** 1983; 49: 210-1.
5. Schiff ER, de Medina MD, Kline SN, Johnson GR, Chan YK, Shorey J, et al. Veterans administration cooperative study on hepatitis and dentistry. ***J Am Dent Assoc*** 1986; 113: 390-6.
6. Look JO, Clay DJ, Gong K, Messer HH. Preliminary results from disinfection of irreversible hydrocolloid impressions. ***J Prosthet Dent*** 1990; 63: 701-7.
7. Infection control recommendations for the dental office and the dental laboratory. Council on Dental Materials, Instruments, and Equipment. Council on Dental Practice. Council on Dental Therapeutics. ***J Am Dent Assoc*** 1988; 116: 241-8.
8. Recommendations for prevention of HIV transmission in health-care settings. ***MMWR Morb Mortal Wkly Rep*** 1987; 36 Suppl 2: 1S-18S.
9. Guidelines for infection control in the dental office and the commercial dental laboratory. Council on Dental Therapeutics. Council on Prosthetic Services and Dental Laboratory Relations. ***J Am Dent Assoc*** 1985; 110: 969-72.
10. Anderson JN. ***Applied Dental Materials***. 5th edition Oxford: Blackwell Scientific Publication; 1977. pp. 205-9.

11. Hayakawa I. ***Principles and practices of complete dentures – creating the mental image of a denture***. London: Quintessence Publishing Co., Ltd.; 1999. pp. 21-46.
12. Hobkirk JA. ***A colour atlas of complete dentures***. London: Wolfe Medical Publications Limited; 1985. pp. 10-12.
13. McCord JF, Tyson KW. A conservative prosthodontic option for the treatment of edentulous patients with atrophic (flat) mandibular ridges. ***Br Dent J*** 1997; 182: 469-72.
14. Bergman B, Bergman M, Olsson S. Alginate impression materials, dimensional stability and surface detail sharpness following treatment with disinfectant solutions. ***Swed Dent J*** 1985; 9: 255-62.
15. Hutchings ML, Vandewalle KS, Schwartz RS, Charlton DG. Immersion disinfection of irreversible hydrocolloid impressions in pH-adjusted sodium hypochlorite. Part 2: Effect on gypsum casts. ***Int J Prosthodont*** 1996; 9: 223-9.
16. Matyas J, Dao N, Caputo AA, Lucatorto FM. Effects of disinfectants on dimensional accuracy of impression materials. ***J Prosthet Dent*** 1990; 64: 25 -31.
17. Rueggeberg FA, Beall FE, Kelly MT, Schuster GS. Sodium hypochlorite disinfection of irreversible hydrocolloid impression material. ***J Prosthet Dent*** 1992; 67: 628-31.
18. Storer R, McCabe JF. An investigation of methods available for sterilising impressions. ***Br Dent J*** 1981; 151: 217-9.
19. Tullner JB, Commette JA, Moon PC. Linear dimensional changes in dental impressions after immersion in disinfectant solutions. ***J Prosthet Dent*** 1988; 60: 725-8.
20. Shen C. Impression materials. In: Anusavice KJ, Shen C, Rawls HR (editors). ***Phillips' Science of Dental Materials***. 12th edition St.Louis: Elsevier; 2013. pp. 151-81.
21. Stanford JW, Paffenbarger GC, Sweeney WT. A revision of American Dental Association specification no. 3 for dental impression compound. ***J Am Dent Assoc*** 1955; 51: 56-64.
22. Herrera SP, Merchant VA. Dimensional stability of dental impressions after immersion disinfection. ***J Am Dent Assoc*** 1986; 113: 419-22.
23. Hilton TJ, Schwartz RS, Bradley DV, Jr. Immersion disinfection of irreversible hydrocolloid impressions. Part 2: Effects on gypsum casts. ***Int J Prosthodont*** 1994; 7: 424-33.
24. Merchant VA. Infection control and prosthodontics. ***J Calif Dent Assoc*** 1989; 17: 49-53.