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COMPARATIVE ASSESSMENT OF DIMENSIONAL STABILITY OF ADDITION SILICONE IMPRESSION UNDER THE EFFECT OF DISINFECTION MATERIALS

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ABSTRACT

AIM OF THE STUDY: The present research attempts to assess the occurred linear changes of additional silicone impressions after utilizing different disinfection materials.

MATERIALS AND METHODS: In the present study, a set of twenty-four impressions of a standard reference model were made using Polyvinyl siloxane impression material. The samples were split to form three groups ($where\ n = 8$) according to disinfection material used; sodium hypochlorite (SH), ozonated water (OW), and a control group (C). Group SH and Group OW were immersed at room temperature for up to 10 minutes. The prepared impressions were investigated before and after the disinfection procedure utilizing Dental Cone beam Computed Tomography (CBCT). Linear measurements were accurately determined between four reference points through the scanned digital models. After disinfection, the dimensional changes were calculated, and statistical analysis was conducted where the p-value was set as $p < 0.05$.

RESULTS: Each linear measurement for the three groups was analyzed using paired measurements before and after the disinfection process. The computed values prior to and following disinfection showed a significant difference when comparing the study groups as ($p < 0.05$). Moreover, the observed significant differences among the study groups were confirmed by applying one-way ANOVA analysis to assess the variance for each measurement.

CONCLUSIONS: The dimensional accuracy of polyvinyl siloxane impression material performed well after using different disinfectant. Impressions were totally immersed in ozonated water showed better stability than impressions were totally immersed in NaOCl.

KEYWORDS: Addition Silicone, Dimensional Stability, Disinfection

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INTRODUCTION

Since the patient's blood and saliva contact the dental impression material, dental healthcare professionals consider exposure to impressions as having the possibility of blood-borne infections transmission (1). Disinfection of impression materials aims to obtain impressions free from saliva or blood-borne infections. To achieve this aim, it is essential to use effective disinfection methods without altering the impressions' dimensional stability. The only safe method to regular care is to presume that any impression ought to be treated in the same manner a high-risk patient's impression would be (2). The British Dental Association released the recommendations for infection control, stating that "the only safe approach to routine treatment is to assume that every patient may be a carrier of an infectious disease" (3).

Noting that, microorganisms are not eliminated from impressions material by only rinsing them with water. Microbiological growth on impressions was reported in the literature, with up to 70% of impressions rinsed with water showing microbial growth (4). Removal of microorganisms from an impression could be achieved using chemical disinfectants. However, the hydrophilicity and wettability of materials

can be influenced by the chemical reactions between the impression material's surface and the disinfectants (5). Therefore, substitutional disinfection techniques with minor deleterious effect to impression materials have been utilized to eliminate microorganisms from the surfaces of used impression materials, which including exposure to ultraviolet light, microwave irradiation, and gaseous ozone (6).

The immersion process is the most trustworthy and efficient technique of dental impressions disinfection since the disinfectant treatment became in direct contact with all surfaces of the tray and impression material (7). Immersion process with various chemical disinfectant solutions has been tested and proven to be appropriate and highly effective for this purpose (8).

The null hypothesis, of the current assessment of the effect of different disinfectants materials, was deemed as there is no difference between the three study groups regarding their dimensional stability.

MATERIALS AND METHODS

These present experimental investigations were approved by the institutional ethics committee of Faculty of Dentistry, Alexandria University.

The present experimental investigations were conducted at the Faculty of Dentistry, Alexandria, Egypt.

A. Fabrication of the master model.

A standard reference model was milled from steel. A horseshoe-shaped model resembling the mandibular arch was designed using CAD software (Delcam; GMBH, Obertshausen, Germany). Five tapered abutments simulating a complete veneer crown preparation were placed in the canine regions (A1, B1) and the first molar region (A2, B2). Hemispherical landmarks were created in the mid of the abutments' occlusal surfaces as reference points. A platform surrounding the model's inferior surface was then designed to avoid custom tray over-seating during the impression procedure. The virtual preliminary model design was transferred to Computer Numerical Control (C.N.C.) milling machine (HURCO BMC20; INDUSTRY PART, Lancaster, United Kingdom) stainless-steel model. The linear measurements selected for the assessment of the dimensional stability after disinfection/sterilization were the inter-abutment distance (A1-A2, B1-B2) and the cross-arch linear-distance (A1-B1, A2-B2) (9).

B. Impressions fabrication

Twenty-four impressions of the master model were made in the present study using a custom tray and a Polyvinyl siloxane (P.V.S.) material using a two-step wash/putty impression technique. The impressions were divided randomly to three groups ($where\ n = 8$) according to the used disinfectant material. Impressions were allowed to polymerize under static load. The pressure standardization was done using a fixed weight then we removed the weight and kept the impression under passive pressure. After the setting of putty, the trays were removed (Express™ S.T.D.; 3M ESPE, Minnesota, U.S.A.). Consequently, The light body (Express-fast Set; 3M ESPE, Minnesota, U.S.A.) was injected into the putty using the auto-mix cartridge dispensing gun (3M™ Garant™ Dispenser; 3M ESPE, Minnesota, U.S.A.)(10). Finally, the tray was seated in the correct position as platform surrounding the model's inferior surface was designed to avoid custom tray over-seating during the impression procedure, and the impression was left undisturbed until a complete setting occurred (9). All 24 impressions were scanned using CBCT (Morita 3DX; J Morita Mfg corp., Kyoto, Japan) as a reference before disinfection.

The impressions were divided randomly to three groups ($where\ n = 8$) according to the used disinfectant material.

Group C: Control group, the eight scanned impressions were left in dry conditions on the bench without disinfection.

Disinfection Process

Group SH: The eight impressions were totally immersed in 0.5% SH (Sodium hypochlorite) solution for ten minutes. Following disinfection, the impressions removed from the disinfection solution were rinsed with tap water for 10 seconds before being dried with compressed air (11).

Group OW: The impressions were subjected to ozonated water produced by the ozone generator device (Ozone Generator, Dongguan Y.P.M., Guangdong, China) with a flow of 2 L/min. An ozone tube with a sterile head was positioned in a sterilized container with distilled water. Ozone tubes were adjusted to the height in the container with an impression tray inside. Then, the ozone generator device was turned on. The disinfection time with the ozonated water was done for 10 min. After disinfection, impressions were removed from the ozonated water and dried using compressed air (12,13).

Three-dimensional analysis of impression material using cone-beam computed tomography

All impressions prepared were scanned via CBCT (Morita 3DX; J Morita Mfg corp., Kyoto, Japan). Before then after

disinfection using the following parameters: tube voltage of 80 K.V.P. and an electric current of 2 mA, for 20 seconds, and a voxel size of 0.125 mm voxel size. The scan was done under a field of view (F.O.V.) of 100 mm X 50 mm. The data was then reconstructed into 3D models and stored as DICOM format (digital imaging and communications in medicine) established by the National Electrical Manufacturers Association. Then the files were imported to a three-dimensional reverse numerical software (Blue Sky Plan® software V4.7; BlueSky Bio L.L.C., Chicago, IL, U.S.A.) to inverse the obtained negative form of the impression image to produce the final digital model with limited segmentation using the same thresholding values for all the models and it is worth to mention that it did not affect the measurements, and the files were exported as stereolithography format (14). A subset of 48 Cone beam computed tomography (CBCT) scans (before and after disinfection for all the groups) were measured independently. For the linear measurements on the digital models, four fixed reference points were used to analyze the dimensional stability of each digital model (15). The scanned 24 impressions were divided randomly to three groups ($where\ n = 8$) and before being disinfected their digital models were measured and the three groups were compared. Then the 24 impression were rescanned after disinfection process again their digital models were measured and the three groups were compared.

Statistical analysis

After the data was collected and coded, descriptive statistics were calculated, including the mean with standard deviation for scale data. Statistical analysis was performed using SPSS version 24 (SPSS, Inc, I.B.M. Corporation, N.Y.C., U.S.A.). Comparative assessment of studied groups concerning all measurements were conducted using One-way ANOVA test followed by Kruskal-Wallis test. Within group comparisons were conducted using paired-T test. Percent change in the measurements was computed through the following formula: $\left[\frac{\text{Final measurements} - \text{initial measurements}}{\text{initial measurements}} \times 100\right]$, where the significance level was set at 0.05

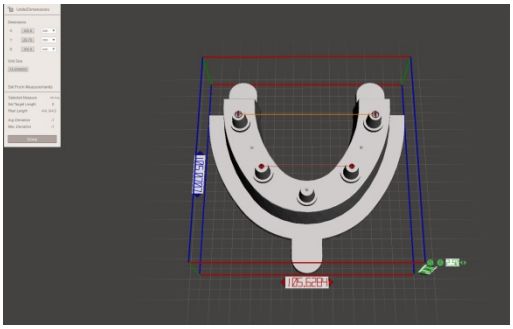

Figure (1): Digital model linear measurements (A1-B1, A2-B2).

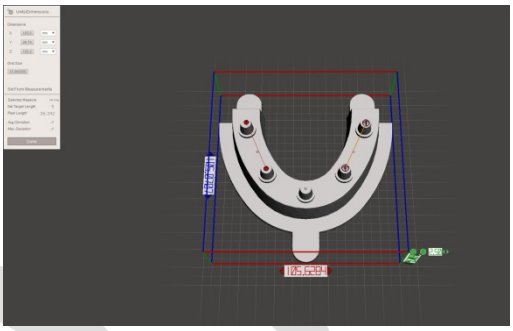

Figure (2): Digital model linear measurements (A1- A2, B1 -B2).

Table (1): Describes the (Mean and SD) of the dimensional differences of linear measurements in mm for three groups regarding (A1-B1, A2-B2, A1- A2, B1 -B2).

Difference value of the measurements		Group I	Group II	Group III	H	P
A1-B1	Min. - Max.	0.017 - 0.032	0.082-0.163	0.077 - 0.115	17.737	<0.05
	Mean± S. D	0.0188 ± 0.006	0.1163±0.02387	0.0950 ± 0.00926		
A2-B2	Min. - Max.	0.012 - 0.035	0.085 - 0.272	0.076 - 0.192	18.304	<0.05
	Mean± S.D	0.0200 ± 0.00756	0.1950 ± 0.07091	0.1025± 0.03991		
B1-B2	Min. - Max.	0.016 - 0.021	0.031-0.108	0.038 - 0.072	16.212	<0.05
	Mean± S.D	0.0138 ± 0.00518	0.0488±0.02357	0.0538 ± 0.01408		
A1-A2	Min. - Max.	0.004 - 0.018	0.031-0.073	0.025 - 0.103	16.245	<0.05
	Mean± S.D	0.0100 ± 0.00756	0.0538±0.01408	0.0438 ± 0.02615		

H: Kruskal-Wallis test

P < 0.05 (significant)

Table (2): Descriptive statistics (Mean and SD) of average deviation in each group.

	Group I (n=8)	Group II (n=8)	Group III (n=8)	H_P
Minimum	0.004	0.031	0.025	19.213 (<0.05)
Maximum	0.035	0.272	0.192	
(%)Change	0.02(0.05%)	0.10(0.31%)	0.07(0.23%)	
Z_P	0.228(0.819)	2.057(0.039)	3.429(0.0006)	

Z: Wilcoxon test
H: Kruskal-Wallis test
* P < 0.05 (significant)

RESULTS

The means and standard deviation (SD) values of measured variation for each linear distance (A1-A2, B1-B2, A1-B1, A2-B2) in the three groups are shown in (Table 1). Changes in the linear measurements of the digital models were compared for all groups (Table 2). According to the linear measurements between reference points identified in the digital models before and after disinfection, Group SH, OW showed a statistically significant difference in the paired analysis ($p < 0.05$). However, the changes in dimensional stability were small in the order of microns. Measured values of the resulted difference before and after procedures were assessed amongst all groups for inter-abutment and cross arch measurements. Comparisons between the different groups during the initial state show no statistical significance difference ($p > 0.05$), while the comparisons between the different groups during the final state confirmed that there was a considerable significance difference ($p < 0.05$).

DISCUSSION

The current study aims to Comparatively assess the resulted effects of two different disinfection materials on the dimensional stability of the additional silicone impression material. The considered null hypothesis of this study was proved to be rejected.

Polyvinyl siloxane (P.V.S.) are the most commonly studied materials after disinfection due to their desirable handling properties and excellent physical properties including greater dimensional stability, precision, higher tear resistance, and better detail reproduction (16). Elastomers have higher extensibility, excellent elasticity after large deformation, great viscoelastic properties, and better detail reproduction (17). However, silicones not only have these properties, but they also display the lowest contraction after setting overtime and the provide the highest dimensional stability of any dental impression material (18).

While P.V.S is hydrophobic by nature; however, this material includes surfactants that enhance its ability to replicate details in a high-humidity environment (19). The presence of these agents upgrades the compatibility of hydrophilic P.V.S with water; the used disinfectant solutions in this research (0.5% sodium hypochlorite and ozonated water) were chosen due to their widespread effects in the reduction of potentially pathogens on impression surfaces (20,21).

The present guidelines of the American Dental Association (A.D.A.) recommended to carefully wash the impressions to remove effectively any attached saliva or blood, followed by immersing them in appropriate disinfecting solutions (8). To maintain the accuracy of the impressions, they are usually exposed to disinfectants for no more than 10-15 minutes. The disinfectant solutions are considered to be appropriate if it have not any effect concerning the dimensional stability of the utilized impression materials (22). Furthermore, silicone did not expand significantly after being disinfected by immersing it in various chemicals for 10 minutes (23). Moreover, insignificant dimensional changes were found when additional silicone impression materials were totally immersed disinfected for ten minutes (24).

Previous research has shown that a 10-minute immersion in sodium hypochlorite can effectively disinfect P.V.S impressions (25-30). Ozonated water has been investigated as an antimicrobial efficacy for disinfection of different impressions materials and proved to be appropriately effective (11, 12, 31). The observed effect of ozonated water on the dimensional stability of P.V.S impressions is almost lacking. Consequently, the present in-vitro study was conducted to assess the potential effect of the freshly prepared ozonated water on dimensional stability and P.V.S impressions.

Recently, the use of Cone Beam Computed Tomography (CBCT) in dentistry has undoubtedly increased, including scanning impressions. Assessing impression materials with a 3D cone beam could be more accurate than traditional techniques, and the obtained images can be generated without influencing

the properties of studied impression (32). The reproducibility and accuracy of CBCT have been examined for the measurements of the three-dimensional implant site and periodontal space, where the CBCT method demonstrating accurate measurements in both cases. CBCT technique was used in a previous study to assess dimension for P.V.C and alginate impression materials (33, 34). This study uses a three-dimensional cone beam C.T. image to assess different disinfectants' effects on P.V.S impressions' dimensional stability.

In the present study, the linear-dimensions were measured through the help of CBCT with accuracy of 0.01 mm, and the mean obtained percentage deviation from the control group was used in order to comparatively assess the dimensional stability of the studied groups. Digital models from impressions disinfected by SH (sodium hypochlorite) and ozonated water immersion showed dimensional change for the inter-abutment and cross-arch linear distance compared with the controls. The mean values of the dimensions were computed before and after disinfection, and the percentage changes of linear dimension was also determined.

The overall mean dimensional change obtained in Group SH was 0.10 mm. The overall mean dimensional change obtained in Group OW was 0.07 mm. The mean linear dimensional change was statistically significant for Group SH &OW ($P < 0.05$). While the mean percentage change in dimension obtained was 0.31% and 0.23% for Group SH OW, respectively. Pairwise ANOVA test for Group SH, OW showed significant statistical differences. However, the differences observed were within ADA specification no. 19 for elastomeric impression materials (The occurred dimensional change of elastomeric impression materials should not exceed 0.5%). When the results were compared to prior research on P.V.S. impressions, related findings were published (33-35). The resulted percentage changes in the considered linear-dimension for Group SH and Group OW were within the clinically acceptable limits and follow the guidelines recommended by Matyas et al (35). as well as in accordance with the recommendations of the conducted study on different impression materials by Jagger DC (36). The addition silicone impression material combination gave the low percentage change in dimensional stability. After disinfection, the percentage changes in the considered linear-dimensions of P.V.S impressions were compared between the studied groups variations of digital scans, and statistically significant dimensional changes were observed between Group SH and Group OW ($p < 0.05$).

CONCLUSION

According to the obtained results and findings of the present in-vitro study, the following conclusions could be drawn:

The selection of the disinfectant material and method for impressions is of the utmost importance as it can greatly induce changes in accuracy and overall stability.

Computing the average linear dimensional-variations of digital scans can be considered as a quick and accurate way for detecting assessed dimensional changes.

The dimensional variations showed significant differences between before and after the disinfection of studied impressions by sodium hypochlorite, ozonated water

The ozonated water displayed less changes as compared to 0.5% sodium hypochlorite, suggesting that it could be used as a substitute disinfectant in clinical practice.

Conflict of Interest

The authors declare that they have no conflict of interest.

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1.Nissan J, Laufer B-Z, Brosh T, Assif D, Maurice T. Accuracy of three polyvinyl siloxane putty-wash impression techniques. The Journal of prosthetic dentistry. 2000;83(2):161-5.

REFERENCES

1. Maller SV, Karthik K, Maller US, Abraham MC, Kumar RN, Manikandan R. Drug and dental impression materials. J pharmacy & bioallied Sci. 2012;4:S316.
2. Hudson-Davies SC, Jones JH, Sarll DW. Cross-infection control in general dental practice: dentists' behaviour compared with their knowledge and opinions. Br Dent J. 1995;178:365-9.
3. Sukhija U, Rathee M, Kukreja N, Khindria S, Singh V, Palaskar J. Efficacy of various disinfectants on dental impression materials. Internet J Dent Sci. 2010;9:1-6.
4. Sofou A, Larsen T, Fiehn N-E, Öwall B. Contamination level of alginate impressions arriving at a dental laboratory. Clin Oral Investig. 2002;6:161-5.
5. Kess RS, Combe EC, Sparks BS. Effect of surface treatments on the wettability of vinyl polysiloxane impression materials. J Prosthet Dent. 2000;84:98-102.
6. Khan M. An overview of dental impression disinfection techniques-A literature review. JPDA. 2018;274:208.

7. Lepe X, Johnson GH. Accuracy of polyether and addition silicone after long-term immersion disinfection. J Prosthet Dent. 1997;78:245-9.
8. Infection control recommendations for the dental office and the dental laboratory. ADA Council on Scientific Affairs and ADA Council on Dental Practice. J Am Dent Assoc. 1996;127:672-80.
9. Emir F, Piskin B, Sipahi C. Effect of dental technician disparities on the 3-dimensional accuracy of definitive casts. J Prosthet Dent. 2017;117:410-8.
10. Hung SH, Purk JH, Tira DE, Eick JD. Accuracy of one-step versus two-step putty wash addition silicone impression technique. J prosthetic dentistry. 1992;583:589-67.
11. Hamedi Rad F, Ghaffari T, Safavi SH. In vitro evaluation of dimensional stability of alginate impressions after disinfection by spray and immersion methods. J Dent Res Dent Clin Dent Prospects. 2010;4:130-5.
12. Savabi O, Nejatidanesh F, Bagheri KP, Karimi L, Savabi G. Prevention of Cross-contamination Risk by Disinfection of Irreversible Hydrocolloid Impression Materials with Ozonated Water. Int J Prev Med. 2018;9:37.
13. Abinaya K, Muthu Kumar B, Ahila SC. Evaluation of Surface Quality of Silicone Impression Materials after Disinfection with Ozone Water: An In vitro Study. Contemp Clin Dent. 2018;9:60-4.
14. Lee SM, Hou Y, Cho JH, Hwang HS. Dimensional accuracy of digital dental models from cone-beam computed tomography scans of alginate impressions according to time elapsed after the impressions. Am J Orthod Dentofacial Orthop. 2016;149:287-94.
15. Hsu K-l, Balhaddad AA, Garcia IM, Collares FM, Dhar V, DePaola L, et al. 3D cone-beam CT imaging used to determine the effect of disinfection protocols on the dimensional stability of full arch impressions. J Saudi Dental 2020
16. Mahalakshmi AS, Jeyapalan V, Mahadevan V, Krishnan CS, Azhagarasan NS, Ramakrishnan H. Comparative evaluation of the effect of electrolyzed oxidizing water on surface detail reproduction, dimensional stability and Surface texture of poly vinyl siloxane impressions. J Indian Prosthodont Soc. 2019;19:33-41.
17. Schmidt A, Häussling T, Rehmann P, Schaaf H, Wöstmann B. Accuracy of various impression materials and methods for two implant systems: An effect size study. J Prosthodont Res. 2018;62:245-51.
18. Amin WM, Al-Ali MH, Al Tarawneh SK, Taha ST, Saleh MW, et al. The effects of disinfectants on dimensional accuracy and surface quality of impression materials and gypsum casts. J Clin Med Res. 2009;1:81-9.
19. Craig RG, Sakaguchi R. Powers JM. Restorative dental materials. St Louis: Mosby; 2002.
20. Vianna ME, Gomes BP, Berber VB, Zaia AA, Ferraz CC, de Souza-Filho FJ. In vitro evaluation of the antimicrobial activity of chlorhexidine and sodium hypochlorite. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2004;97:79-84.
21. Białoszewski D, Bocian E, Bukowska B, Czajkowska M, Sokół-Leszczyńska B, Tyski S. Antimicrobial activity of ozonated water. Med Sci Monit. 2010;16:MT71-5.
22. Chidambaranathan AS, Balasubramanium M. Comprehensive Review and Comparison of the Disinfection Techniques Currently Available in the Literature. J Prosthodont. 2019;28:e849-56.
23. AlZain S. Effect of chemical, microwave irradiation, steam autoclave, ultraviolet light radiation, ozone and electrolyzed oxidizing water disinfection on properties of impression materials: A systematic review and meta-analysis study. Saudi Dent J. 2020;32:161-70.
24. Ahila S, Thulasingam C. Effect of disinfection on gypsum casts retrieved from addition and condensation silicone impressions disinfected by immersion and spray methods. SRM J Res Dent Sci. 2014;5:163- 9.
25. Duseja S, Shah RJ, Shah DS, Duseja S. Dimensional measurement accuracy of recent polyether and addition silicone monophase impression materials after immersion in various disinfectants: An in vitro study. Int J Healthcare Biomed Res. 2014;2:87-97.
26. Bhat VS, Shetty MS, Shenoy KK. Infection control in the prosthodontic laboratory. J Indian Prosthodont Soc. 2007;7:62-5.
27. Taylor RL, Wright PS, Maryan C. Disinfection procedures: their effect on the dimensional accuracy and surface quality of irreversible hydrocolloid impression materials and gypsum casts. Dent Mater. 2002;18:103-10.

28. Anusavice KJ, Shen C, Rawls HR. Phillips' science of dental materials: Elsevier Health Sciences; 2012.
29. Sakaguchi RL, Powers JM. Craig's restorative dental materials.13th ed. Philadelphia, PA: Elsevier Inc; 2012.
30. Atabek D, Alaçam A, Tüzüner E, Polat S, Sipahi AB. In-vivo evaluation of impression material disinfection with different disinfectant agents. Hacettepe Dişhekimliği Fakültesi Derg (Clinical Dentistry and Research). 2009;33:52-9.
31. Egusa H, Watamoto T, Matsumoto T, Abe K, Kobayashi M, Akashi Y, Yatani H. Clinical evaluation of the efficacy of removing microorganisms to disinfect patient-derived dental impressions. Int J Prosthodont. 2008;21:531-8.
32. Karaaslan G, Malkoc MA, Yildirim G, Malkoc S. Comparison of time-dependent two-dimensional and three-dimensional stability with micro-computerized tomography and wettability of three impression materials. Niger J Clin Pract. 2018;21:912-20.
33. Al-Ekrish AA. Effect of exposure time on the accuracy and reliability of cone beam computed tomography in the assessment of dental implant site dimensions in dry skulls. Saudi Dent J. 2012;24:127-34.
34. Hsu KL, Balhaddad AA, Garcia IM, Collares FM, Dhar V, DePaola L, et al. 3D cone-beam CT imaging used to determine the effect of disinfection protocols on the dimensional stability of full arch impressions. Saudi Dent J. 2020;1-9.
35. Matyas J, Dao N, Caputo AA, Lucatorto FM. Effects of disinfectants on dimensional accuracy of impression materials. J Prosthet Dent. 1990;64:25-31.
36. Jagger DC, Vowles RW, McNally L, Davis F, O'Sullivan DJ. The effect of a range of disinfectants on the dimensional accuracy and stability of some impression materials. Eur J Prosthodont Restor Dent. 2007;15:23-8.