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Dimensional Stability of Autoclave Sterilised Addition Cured Impressions and Trays

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Abstract - *The aim of this study was to investigate the dimensional accuracy of impressions following sterilisation by autoclaving. Dental impressions (75) were of a dentoform containing 6 reference points. The impressions were split into 5 groups of 15, each group used a different impression technique. Groups were divided into 3 subgroups with 5 impressions as control, 5 for disinfection by Perform-ID and 5 being autoclaved. Measurements were made using a travelling light microscope. A minimal significant dimensional difference (0.01<P<0.05) was observed when using the one-stage impression method. No significant dimensional differences were observed for all other groups (P>0.05). The trays and materials tested were suitable for the autoclave sterilisation.*

KEYWORDS: impressions, trays, stability, sterilisation, autoclave

INTRODUCTION

Dentists are continuously under pressure to maintain the hygiene of their practice and avoid the spread of infection between patients and members of the dental team. For non-disposable instruments which have come into contact with oral tissue, autoclave sterilisation is the cleaning method of choice. However, for set dental impressions, current protocol calls for disinfection only.

Disinfection has been defined as a process of killing some but not all pathogenic bacteria or microorganisms. Sterilisation is also used to destroy all living microorganisms (including bacterial spores) from an article using either heat and high pressure or chemical means. Saliva is a carrier for numerous pathogenic bacteria and Powell *et al* .[1] found that in a sample of 100, 67% of impressions were found to carry such organisms as *E. coli*, *Enterobacter cloacae* and *Klebsiella oxytoca*, alongside many more. A study carried out in Hong Kong[2] found that only 48% of the dentists surveyed disinfected their impressions and only 74% rinsed their working impression after removal from the mouth. A similar recent study in Ireland revealed that 18% of dentists still do not disinfect their impressions[3].

There is a possibility of a non-sterile, or perhaps even a non disinfected impression being sent to a dental laboratory, perhaps through a postal or delivery system and handled by personnel not fully aware of necessary protective measures. There is also a theoretical risk of transfer of infections to the laboratory and subsequently to other practices through contact with other patients' prostheses. In order to eliminate these risks best practice would be to remove pathogens at the earliest opportunity and so it is recommended that sterilisation should take place before the dental impression is allowed to leave the dental office.

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Olin *et al* .[4] reported the use of ethylene oxide gas autoclaving of heavy and light bodied addition silicone impression material in custom autopolymerising acrylic resin trays. The results of this study showed that there were significant structural changes (>0.5% change) occurring post-autoclaving suggesting that this is due to the distortion of the trays themselves or their incapability to prevent expansion of the impression material. Another study[5] showed that polyvinylsiloxane (addition cure silicone) impression materials (President, Coltene) can be autoclaved without any significant dimensional changes using stock metal trays, albeit, should be viewed cautiously when sterilised at 132°C. This was further supported by Millar *et al* .[6] using addition cured silicone impressions autoclaved at 134°C producing less than 0.5% dimensional change. Given that there is now evidence that impression materials can be autoclave sterilised, and that clinical practitioners prefer sterilisation in general, a suitable type of tray needed to be manufactured and tested. Such a tray recently became available along with a heat resistant adhesive.

The aim of this *in vitro* study was to determine the suitability of a new autoclavable impression tray and its ability to withstand autoclaving using different popular impression techniques.

MATERIALS AND METHODS

Custom-made autoclavable plastic trays (Figure 1) specifically developed by Coltene were used for this study. A newly formulated spray-on chemical adhesive was used to further retain the impression material within the trays. The impression materials were all addition silicone (Affinis putty soft, Affinis heavy body, Precious Light Body and Precious Regular Body wash) as these have been shown previously to be suitable for autoclave sterilisation.

A Columbia dentoform lower model was used for impression recording Reference points were placed on the model (Figure 2) using a dental drill in 6 (A-D, X-Y) different areas to act as reference indentations. Point A is

located on the lower left first molar (19), point B - lower right second molar (31), point C - lower right canine (27), point D - lower left first premolar (21), point X - lateral left side of the gum under lower left first premolar and point Y – lateral right side of the gum under lower right second molar. By doing so, we were able to obtain measurements in X, Y and Z planes.

The study was split into 5 groups (Table 1). Each group consists of 15 impressions, 5 for control (untreated), 5 for disinfection in Perform ID (Shulke & Mayr UK Ltd) and 5 to be autoclaved, resulting in a total of 75 dental impressions. Each group of 15 impressions used a different impression technique. All trays, except those of group 5, were sprayed evenly on the inside with the new tray adhesive. The adhesive is left to dry on the tray for 3 minutes upon each application.

Group 1 was carried out using the popular UK method of impression recording using one stage putty and wash. This technique consisted of filling the autoclavable Coltene dental trays with Putty soft, then applying Precious Regular body wash material to the lower jaw model and placing the tray on the dentoform. When mixing the putty, latex gloves were not worn as the sulphur used to treat the gloves may inhibit the set of the impression material[7]. The Precious Regular body wash material was applied on all teeth on the dentoform. As it has been recommended for

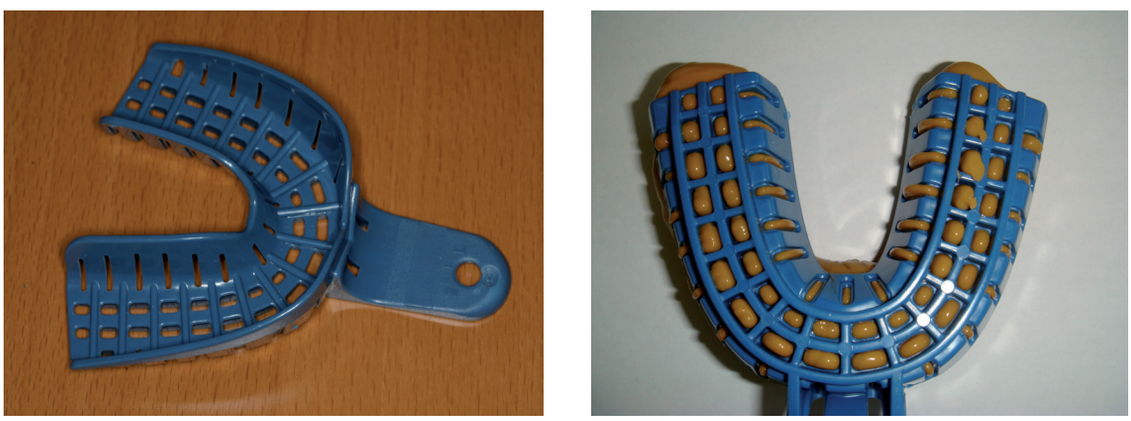

Figure 1. *Autoclavable plastic tray (Coltene).*

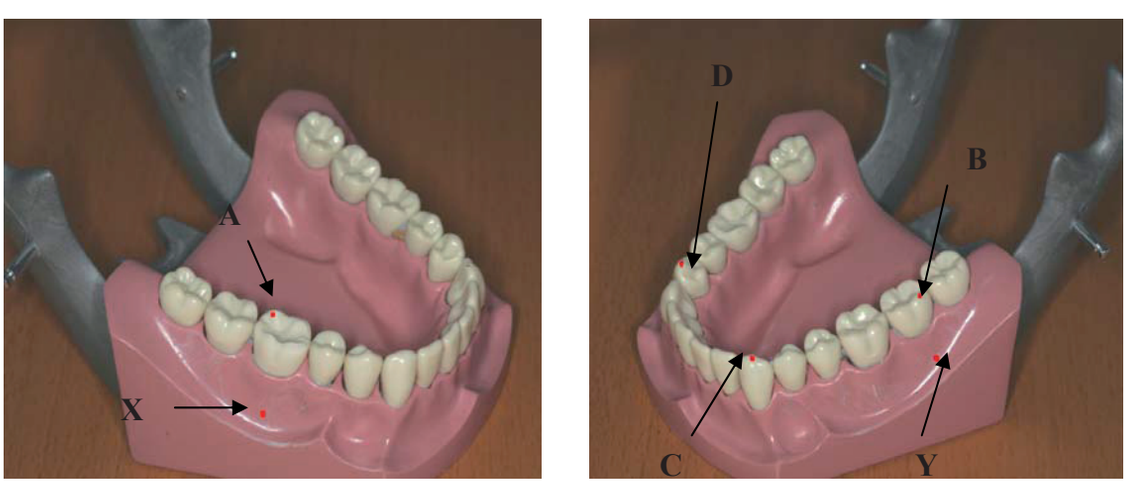

Figure 2. *Lower dentoform model used including indentations drilled to act as reference points. Reference points A-D and X-Y labelled with arrows and marked in red.*

Table 1. *The 5 test groups and the individual methods of impression material application and type of impression material used*

Group	Impression Materials	Stage	Tray
1	Putty Soft, Precious Regular Body	One	Modified Plastic Tray
2	Putty Soft, Precious Regular Body	Two	Modified Plastic Tray
3	Heavy Body, Precious Light Body	One	Modified Plastic Tray
4	Heavy Body, Precious Light Body	Two	Modified Plastic Tray
5	Heavy Body, Precious Light Body	One	Quad Tray Xtreme

Each group consisted of either variation in impression material or impression material application method. Modified plastic trays provided by Coltene. Quad Tray Xtreme trays are metallic.

addition silicone impression materials to be left to set for about 6 minutes at temperatures of 37°C[8], the model was left to set for the duration of 6 minutes with a weight of 400g placed on top so as to mimic the force that would be exerted by the dentist on the patient's teeth had the impressions been taken naturally. Once all 15 impressions had been produced, 5 were randomly selected for autoclaving, another 5 for disinfection and the last 5 left as a control group.

Group 2 used a two stage putty and wash technique. The Affinis Putty Soft was initially applied to the tray and left to set on the dentoform, then removed in order to add the Precious Regular Body wash to the model and then the putty was replaced until the wash had set.

Group 3 used a universally accepted one-stage technique with heavy body and light body materials combined. The same process as group 1 was repeated except the putty was replaced with Affinis Heavy Body in the tray applied using the dispenser provided by the manufacturer. The heavy and light body were applied thickly, ensuring that the entire tray was covered with enough depth to cover all reference points. Group 4 is similar to group 3, except that it is applied as a two stage process (similar to that of group 2).

Finally, group 5 utilised the dual-arch impression technique using a Quad Tray Xtreme. These trays are aluminium dual arch impression trays and claim to be considerably less flexible and more stable than dual arch plastic trays due to the presence of retention bars. These trays were used with Affinis Heavy Body and Affinis Precious Light Body, as in group 3, but as a one stage process. As the Quad Tray Xtreme trays can only take impressions of half of the mouth at any one time, the right hand side was chosen so more points of reference could be taken into the final impression (points A, D and X). Due to the structural nature of the Quad Tray Xtreme trays, it was necessary to attach an upper dentoform to the lower so that the two arches could be brought together into the tray.

The 25 impressions allocated for disinfection were individually immersed in 2% Perform-ID for 10 minutes, as practiced in many UK clinics, as recommended by the manufacturer. The impressions were then rinsed under normal tap water for 30 seconds, then gently shaken and bagged for analysis. The 25 impressions to be autoclaved were sealed in separate bags and sent to the sterilisation department of King's College Hospital to be sterilised using the standard cycle, at 134°C for half an hour (including drying time), as is used for sterilising normal dental equipment. Each group was treated on the day they were created. All impressions were then stored for measurement and analysis for dimensional change. The final 25 impressions were retained as controls and were stored untreated.

All impressions were measured using a travelling light microscope at X0.7 magnification (Starrett Kinemetric EZ48-6-300) with a resolution accuracy of ±0.05µm, connected to a Quadra-check 300 screen. Measurements were obtained by determining the distance between the 6 reference points A-B, B-C, C-D, D-A and X-Y. For impression groups 1-4, all 6 reference points were used for measurement (Figure 3). For group 5, due to the structural difference of the Quad Xtreme trays, only points A-D, D-X and X-A were measured as impressions were only taken from the right side of the mandibular model (Figure 3). The distances between each point for all groups were measured three times in order to obtain a mean set of values so as to ensure an accurate representation of the results.

One way ANOVA test was used to determine statistically significant dimensional differences between groups and Tukey tests (a pairwise multiple comparison test) were then used to determine whether any significant dimensional changes had occurred amongst the impressions in each treatment group. Any statistically significant (95%) dimensional change between groups would be considered to have a potential clinical significance which would require consideration.

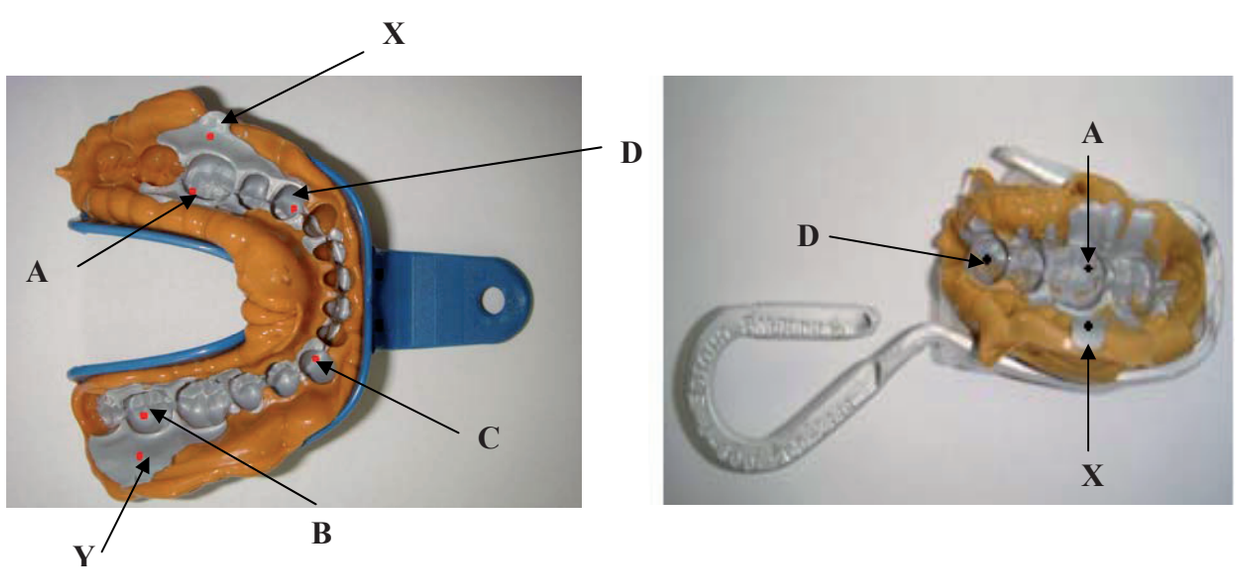

Figure 3. *Modified Plastic Tray with Heavy Body and Light Body (Group 4-Disinfected sample). Reference points A-D, X-Y marked by red circles and labelled. Quad Tray Xtreme Tray with Heavy Body and Light Body (Group 5-Autoclaved sample). Reference points A, D and X marked by black circles and labelled accordingly.*

RESULTS

The Tukey test was used as a pair wise multiple comparison test which is useful for determining differences in samples of independent groups. This test corrects the experiment-wise error rate. The results from the Tukey test varied but indicated that there was no overall significant dimensional change across the control, disinfected and autoclaved specimens in all five groups. The test was carried out at 95% certainty level, where p=3.77 and at 99% certainty level where p=5.50, where there are 12 degrees of freedom and k=3, using the studentized range distribution (q) table. Disinfection and autoclaving did not distort the shape of the trays nor that of the impression material as no statistically significant dimensional change was observed and this suggests that no clinically significant effect would therefore be present.

Comparison between control groups and disinfection treated groups using the ANOVA test and Tukey test proved to show no overall significant difference. Impressions immersed in disinfection incurred no significant dimensional change in any dimensional plane.

Comparison of autoclaved trays with that of the control trays was carried out in the same manner as that with the disinfection treated trays using the Tukey test and ANOVA analysis. The results proved promising as little variance in dimensional change was observed fulfilling the initial hypothesis.

Group 1 (see Table 1) only showed significant differences in dimensions A-B (F=9) and D-A (F=6) and all other dimensions were dimensionally stable at a 95% certainty level using the ANOVA test. The Tukey test showed that the reason behind the significant difference in the ANOVA test for dimension A-B was due to the dimensional change in the autoclaved group in comparison to both the control ($p<0.01$) and disinfected group ($p<0.01$). The dimensional change in dimension D-A was found to be due to significant changes in the disinfection treated group in comparison to both control ($0.01<p<0.05$) and autoclaved groups ($0.01<p<0.05$). The Tukey test also showed that significant changes were present in B-C between the disinfection treated group and the control group ($0.01<p<0.05$) as well as with the autoclaved group ($0.01<p<0.05$), however the ANOVA test did not determine this change to be significant overall.

Group 2 showed no overall significant dimensional change across all dimensions according to the results of the ANOVA test. The Tukey test showed significant dimensional changes at 95% certainty levels in dimensions B-C between the control and disinfection group ($0.01<p<0.05$), as well as the control and autoclaved group ($p<0.01$). Tukey's test also showed a significant difference in dimension X-Y between the control and disinfection treated groups ($p<0.01$), as well as between the control and autoclaved groups ($0.01<p<0.05$).

Group 3 was found to have significant dimensional changes for the dimensions A-B (F=4.5) and D-A (F=6.6) using ANOVA. Tukey's test showed that the reason behind the significant changes A-B were due to the changes between the autoclaved and control groups ($p<0.01$) as well as the autoclaved and disinfected groups ($p<0.01$). The significant changes in D-A were found to be due to the significant difference between the disinfected and autoclaved groups ($p<0.01$). The test also showed that there were significant dimensional changes for dimensions C-D between the disinfected and autoclaved groups ($0.01<p<0.05$) and X-Y the autoclaved and control groups ($p<0.01$) as well as the autoclaved and disinfected groups ($p<0.01$). However, according to the ANOVA test, these changes were not significant overall.

Group 4 was shown to have no overall significant dimensional change across all groups using the ANOVA test. The Tukey test however, showed significant dimensional changes for dimensions A-B between the disinfected and autoclaved groups ($p<0.01$), C-D between the autoclaved and control groups ($p<0.01$), D-A between autoclaved and disinfected groups ($p<0.01$) and X-Y between the autoclaved and control groups ($p<0.01$).

Group 5 showed no significant dimensional change over all dimensions between all treatments in all groups according to both the ANOVA test and the Tukey test.

Results from measurements of the reference points for each tray in each group and calculating their mean distances yielded little variance. The mean comparisons of each dimensional measurement between the three different treated subgroups per group proved very similar in almost all cases, showing very little deviation (Figure 4). Table 2 and 3 show the mean distances between each reference point for each group in each experimental condition as well as their individual standard deviations and standard error means.

Standard deviations across all groups and treatments remained at a low level, with the highest deviation at ±1.84 mm for dimensions X-A in group 5. Standard error means for all groups did not exceed ±0.82 mm (group E, X-A).

DISCUSSION

Autoclaving is the accepted means to eliminate the spread of diseases via contaminated non-disposable instruments[4]. Studies have shown that disinfection of impressions and their trays without causing significant dimensional distortion, however disinfection is less satisfactory than autoclaving[9].

Two studies[5,6] found that it is possible to autoclave addition silicone cured impression materials without causing significant dimensional distortion in metal trays. Standard plastic trays have been shown to suffer significant dimensional changes when undergoing sterilisation by autoclaving resulting in inaccurate casts being produced[4]. Hence the launch of the modified plastic trays used in this study, which were designed to withstand standard autoclaving cycles at 134ºC. Comparisons of these trays undergoing three treatments, no treatment, disinfection and autoclaved, were carried out and presented no overall significant dimensional changes at a 95-99% certainty level. This finding was observed across all 5 groups. Using the Tukey test, it was possible to decipher which findings were causing the variation of the F value found using ANOVA test.

The minor variations present between the control and disinfection treated groups could be due to experimental error as previous studies have shown that there is unlikely to be tray distortion post disinfection in Perform[10].

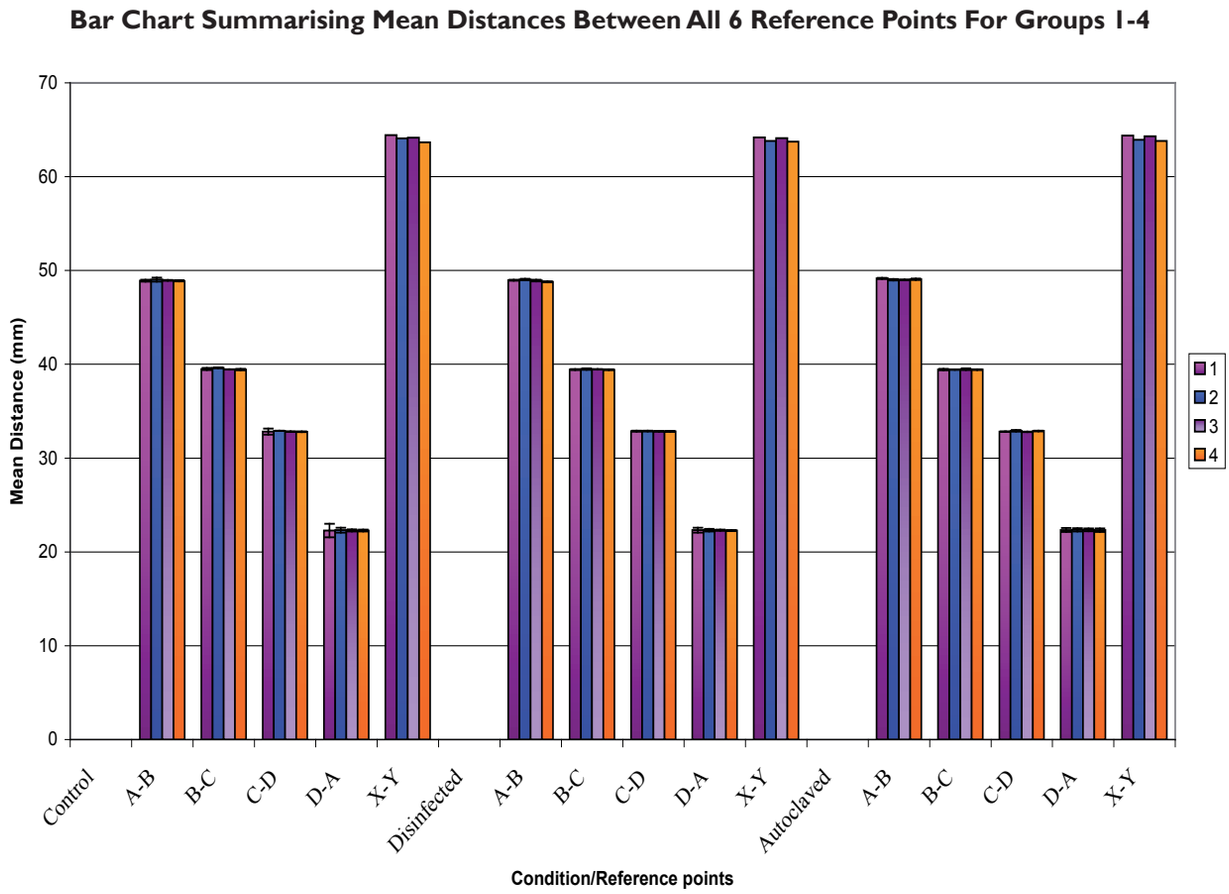

Figure 4: *mean dimensional stability values (n = 5) calculated using means of distances between reference points (mm) A-B, B-C, C-D, D-A and X-Y with error bars representing standard deviation (some dimension have very small error bars which do not show up using Excel) for groups 1-4. Control = no treatment; Disinfection = immersion in Perform-ID for 10 minutes; Autoclaved = sterilised at standard cycle at 134°C. Group 1: Affinis putty soft and Precious Regular Body (one stage); Group 2: Affinis putty soft and Precious Regular Body (two stage); Group 3: Affinis Heavy Body and Precious Light Body (one stage); Group 4: Affinis Heavy Body and Precious Light Body (two stage).*

Table 2. *A comparison of the Dimensional Stability values of 4 groups of full arch dental impression trays varying in impression material and application method which have undergone no treatment, disinfection and dental autoclave*

Group	*1*		*2*		*3*		*4*	
Control	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*
A-B	0.12	48.92	0.07	49.03	0.02	48.95	0.08	48.9
B-C	0.10	39.5	0.21	39.62	0.04	39.46	0.07	39.44
C-D	0.12	32.82	0.04	32.91	0.01	32.82	0.08	32.81
D-A	0.33	22.28	0.02	22.32	0.03	22.29	0.04	22.28
X-Y	0.73	64.42	0.27	64.09	0.12	64.16	0.1	63.67
Disinfected								
A-B	0.03	48.96	0.05	49.03	0.07	48.93	0.4	48.78
B-C	0.04	39.44	0.07	39.49	0.08	39.46	0.05	39.42
C-D	0.04	32.87	0.07	32.88	0.03	32.86	0.04	32.85
D-A	0.05	22.32	0.04	22.32	0.04	22.31	0.04	22.27
X-Y	0.26	64.18	0.14	63.81	0.06	64.11	0.05	63.73
Autoclaved								
A-B	0.10	49.15	0.03	49.02	0.02	49	0.08	49.06
B-C	0.07	39.44	0.07	39.43	0.03	39.47	0.07	39.43
C-D	0.07	32.82	0.02	32.91	0.09	32.8	0.04	32.89
D-A	0.00	22.34	0.08	22.35	0.02	22.36	0.04	22.32
X-Y	0.21	64.39	0.17	63.93	0.15	64.3	0.18	63.8

Reference points (A-B, B-C, C-D, D-E, X-Y) on each sample were measured using a light travelling microscope following disinfection, sterilisation or no treatment. Standard deviations (SD) were calculated using the means (in millimetres) obtained.

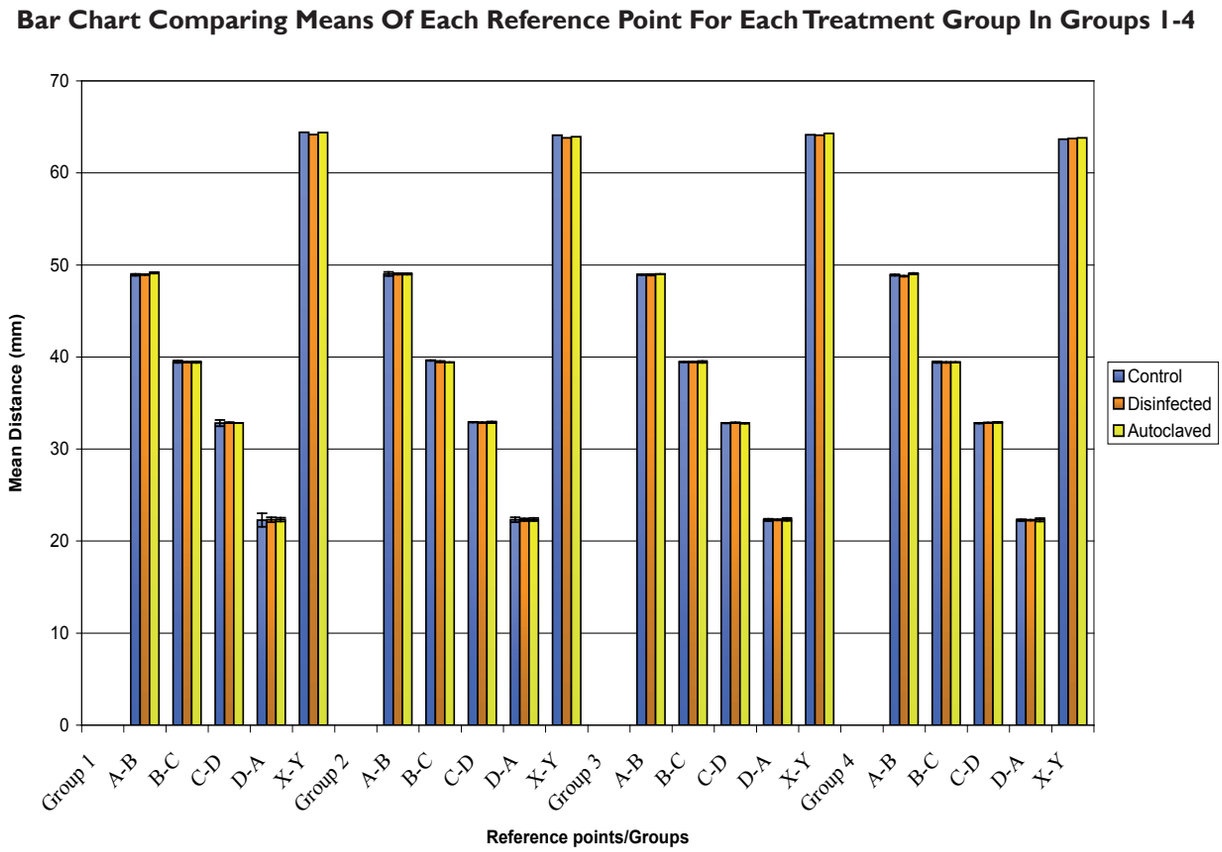

Figure 5. *Mean dimensional stability values (n = 5) calculated using means of distances between reference points (mm) A-B. B-C, C-D, D-A and X-Y with error bars representing standard deviation (some dimensions have very small error bars which are not visible) for groups 1-4. Control = no treatment; Disinfection = immersion in Perform-ID for 10 minutes; Autoclaved = sterilised at standard cycle at 134°C. Group 1: Affinis putty soft and Precious Regular Body (one stage); Group 2: Affinis putty soft and Precious Regular Body (two stage); Group 3: Affinis Heavy Body and Precious Light Body (one stage); Group 4: Affinis Heavy Body and Precious Light Body (two stage).*

Table 3. *A comparison of the Dimensional Stability values of dual arch dental impression trays varying in impression material and application method which have undergone no treatment, disinfection and dental autoclave*

Group	*5*	
Control	*SD*	*Mean*
A-D	0.24	22.09
D-X	0.87	19.99
X-A	0.56	12.13
Disinfected		
A-D	0.17	22.08
D-X	1.77	19.35
X-A	1.7	11.55
Autoclaved		
A-D	0.17	22.13
D-X	0.52	19.01
X-A	1.84	10.16

Reference points (A-D, D-X and X-A) on each sample were measured using a light travelling microscope following disinfection, sterilisation or no treatment. Standard Deviations (SD) and Standard Error Means (SEM) were calculated using the means (in millimetres) obtained.

Comparison of the modified plastic trays undergoing no treatment to those of which were autoclaved showed certain significant differences, more so than that of disinfection treated trays. If the autoclaved trays have suffered distortion, they would be expected to show significant differences in comparison to the disinfected trays. Differences occurred in almost all dimensions of the autoclaved impression trays in group 3.

Group 3 uses a lower viscosity wash material Precious Light Body and Affinis Heavy Body. These materials were applied using the one-stage method. Group 4 uses the same impression and wash material, however using the two-stage method. Group 4 did not present an overall significant dimensional change according to the ANOVA test. Significant dimensional changes were observed in two dimensions when comparing the autoclaved trays to that of control. The same materials and tray types were used in both group 3 and 4, the only variable that differed was the number of stages in the process. It is possible that such changes present in group 3 could be accounted for by Caputi's findings[11] that final impressions are less accurate when using the one-stage process, as otherwise the same findings would have been present in both group 3 and group 4. Since the one-stage method is susceptible to producing inaccurate final impressions,

therefore, possible variations can be exaggerated by the autoclaving process. The same can be said for group 1 and 2, where group 1 was carried out using the one-stage process and 2, using the two-stage. Both group 1 and 2 exhibited significant dimensional change using the Tukey test when comparing the control and disinfection treated groups. Such dimensional changes can be accounted for by the process of imbibition which has been thought to occur during disinfection[12].

Group 5 also used the same impression materials as group 3 and 4 and was carried out using the one-stage method, however using the Quad Tray Xtreme trays. Quad Tray Xtreme trays are metal and so are able to withstand autoclaving. No significant dimensional differences were observed across all dimensions in all 3 treatment conditions. This suggests that the one-stage method is possibly more suited to be applied when using metal trays. Group 5 further demonstrated the autoclavable nature of the impression and wash materials as no significant dimensional change occurred post autoclaving as well as that of the Quad Tray Xtreme trays.

Therefore it could be postulated that these autoclavable trays produce more accurate final impressions post autoclaving when using the two-stage process. The modified trays are able to maintain their dimensional stability as well as that of the impression material only for certain methods of impression taking, hence their ability to produce accurate impressions is dependent upon the impression technique and method of impression material application. The results also imply that Putty Soft (Affinis) impression material with Regular Body (Precious) wash material maintain their dimensional stability more so than those of Heavy Body (Affinis) impression material and Light Body (Precious) wash material when in use with these trays, as the least dimensional change occurred in groups 1 and 2 in comparison to that of group 3 and 4.

Studies have shown that putty/wash impression techniques tend to be less accurate than that of polyether (heavy and light body) impressions[13] as polyether impressions have lower viscosity and hence can produce lines 1-2 μm wide[14], whereas all other types of viscosity lead to lines 0.020 mm wide[15]. This could explain as to why it may seem that the putty/wash technique suffered less significant dimensional changes in comparison to the trays using heavy and light body. It could also serve as an explanation as to the significant dimensional changes observed between the control and disinfection treated groups in groups 1 and 2. However, lower viscosity impression materials have been shown to produce the greatest change due to polymerisation shrinkage (up to 0.02-0.05% shrinkage) due to their lower filler content[16] and so they are more susceptible to variation in accuracy.

With over 50% of dentists showing preference towards autoclaving as their choice of hygiene control for impression materials[2], autoclavable or heat resistant trays will substantially save time and control spread of infection in the clinic. Hygiene control is paramount in the clinical setting, one study found that 61.3% of dental impressions, which had been claimed to be disinfected, demonstrated bacterial growth similar to those present in non-disinfected impressions[17]. It is clear from such results that standard disinfection is not sufficient in preventing spread of bacteria, nor does it guarantee protection against possible new species of pathogen. Sterilisation is the only method that guarantees 100% killing of all bacterial organisms on dental impressions with convenience and at a low cost.

This present study shows that the modified plastic trays provided by Coltene are able to withstand the autoclaving process without distortion and produce dimensionally accurate final impressions. The dimensional differences observed between the currently accepted disinfection method and the proposed autoclaving method does not produce a statistically significant dimensional difference and so is unlikely to produce a clinical difference. This is particularly the case as the dimensions measured in this study were often cross-arch and so much greater than required in clinical practice where the majority of impressions only require high levels of accuracy across a few neighbouring teeth. The clinician might select putty and regular body in a two stage technique as the impression technique of choice. Further clinical testing should be carried out using variety of impression materials as well as other impression application techniques. The modified trays may also be further modified, such as colour change, so as to indicate whether they have undergone the autoclaving process or not.

CONCLUSION

Hygiene control and management of cross-infections has become a paramount issue in dentistry and amongst other healthcare industries. Previous studies have shown that disinfection is not sufficient or efficient in completely eradicating bacteria on dental impressions. The clinical implications of this laboratory study is such that dental impressions created using addition cured silicone with the modified plastic dental trays, when compared to untreated and disinfection treated trays, can produce dimensionally accurate final impressions.

ADDRESS FOR CORRESPONDENCE

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