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The Effect of Disinfection on Irreversible Hydrocolloid and Type III Gypsum Casts

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Abstract - *Under standardised conditions, 80 impressions were made of a ruled stainless steel die (ISO Specification 1563) using irreversible hydrocolloid (alginate). The alginates were subsequently treated with 3 commercially available disinfectants, Perform-ID, ImpressiV and Dimenol and poured with type III gypsum. The alginates were evaluated for surface detail reproduction and the gypsum for surface detail reproduction and hardness. Disinfection with Perform ID significantly affected the surface detail reproduction of alginate while Dimenol and ImpressiV did not. Perform ID and Dimenol both significantly affect the hardness of poured type III gypsum casts while ImpressiV did not.*

KEY WORDS: Irreversible hydrocolloid, disinfection, surface detail reproduction, hardness

INTRODUCTION

Irreversible hydrocolloid (alginate) is a common impression material used to produce gypsum stone casts. ISO Specification 1563 states that an alginate material must be able to reproduce a 50µm line on the test die (Fig.1) and for it to be visible on the subsequent gypsum cast[1].

Dental impressions are often contaminated with micro-organisms from the mouth[2,3,4]. Gypsum casts poured against such impressions were shown to be contaminated[5]. There is a potential for disease transmission by handling such contaminated impressions[6]. The increasing frequency of acquired immune deficiency syndrome, Hepatitis B and tuberculosis has led to a particular interest in disinfection and sterilisation procedures[7,8,9], with all patients being considered potentially infectious[10]. To reduce the potential for cross contamination between clinical area and laboratory, the sterilisation of impressions by dry or moist heat is unsuitable and, therefore cold disinfection must be used for this purpose[11]. The commonly used chemical disinfectants are alcohols, aldehydes, chlorine compounds, phenolics, biguanides, iodine compounds and quaternary ammonium compounds[12]. Three methods of cold disinfection exist: soaking, spraying and mixing with, or as a substitute for, water used to mix alginate.

The ideal disinfection procedure must leave the physical and chemical properties of the impression material and gypsum cast unchanged to achieve accuracy of the final prosthesis. Reports on the effect of disinfection of alginates on the dimensional accuracy, surface detail reproduction and surface hardness of subsequent gypsum casts are contradictory [4,13-23].

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The null hypothesis of this study states that disinfection will have no significant effect on surface detail reproduction of alginate impressions or surface detail reproduction and hardness of resultant type III gypsum casts.

MATERIAL AND METHODS

The experimental methodology was carried out in accordance with the tests described in ISO 1563 specifications[1]. The alginate powder was kept in a closed container and the test equipment was conditioned for a minimum of 10 hours at 23°C +/- 2°C, the distilled water was also maintained at 23°C. In order to standardise the alginate powder to water ratio, one scoop of powder was weighed and found to be 9.0 g in weight. This weight was used for fabricating all the specimens. The amount of distilled water was measured in millilitres (ml) and for one scoop of powder the recommended 20ml of water were used. The water bath testing temperature was set at 35 +/-1°C as it offered a heating rate of the test specimen comparable to the heating rate of impression material under oral conditions[1].

The ISO stainless steel test die (Ravensfield Design, Lancashire, UK) inscribed with 3 horizontal and 2 vertical lines is shown in Figure 1. Alginate was mixed with water in a mixing bowl for a period of 60 seconds as per manufacturer's instructions. The mixture was made to be homogeneous, free from lumps and forming a smooth plastic mass. Eighty alginate impressions of the ISO test die were made. The alginate specimens were then immediately disinfected following manufacturers' protocols.

Manufacturers disinfection protocols

- **Perform ID-** Rinse impression with water, place in Perform ID bath for 10 minutes and then remove and rinse with water.
- **Dimenol-** Spray Dimenol onto the impression material in order to moisten evenly. Leave it in contact for 15

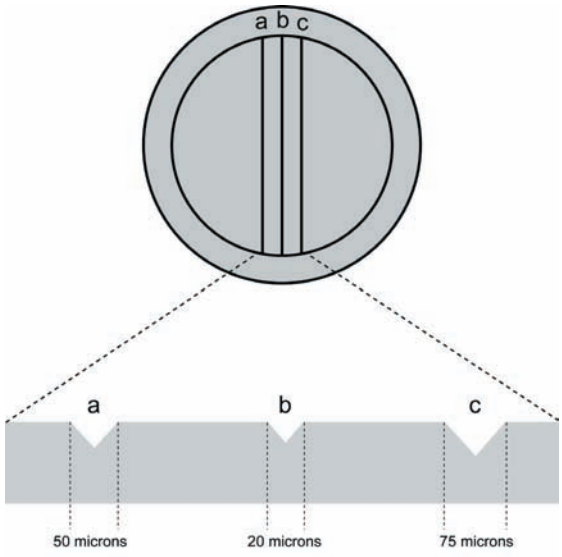

Figure 1. *Diagrammatic representation of ADA test die. Surface detail reproducibility of impressions and associated casts was measured via qualitative assessment of the reproduction of line 'a'.*

minutes. Rinse with water.

- **ImpressiV-** Rinse impression thoroughly under running water to remove all visible contamination. Shake off excess water. Spray ImpressiV directly onto impression ensuring complete coverage. Allow impression to dry.
- **Control** - The impression was rinsed with water, and then placed in a bath containing distilled water for 10 minutes, removed and rinsed with water.

Spray disinfection was undertaken at a set 10cm distance parallel to the impression material. After the disinfection period the alginates were immediately poured with a type III gypsum product using manufacturer's recommended water/powder ratios and vacuum mixing. Beginning from one end of the groove on the surface of the block, impressions were poured using vibration at a slight angle. A fine instrument was used to aid the flow of material along the lines and the initial gypsum was poured away from the impression to allow for moisture contamination. Twenty specimens for each experimental group and the control were made. The gypsum casts were removed two hours after pouring.

ISO specification 1563 states that an alginate material must be able to reproduce a 50µ line[1]. Using a microscope at 12 x magnification with standardised low angle (20 degrees) illumination, 2 independent examiners randomly examined the alginates impressions before and after disinfection and subsequently poured gypsum casts and scored the reproducibility of the 50µm horizontal line (Figure 1, line a). If the line was reproduced fully the specimen received the score of 1 and if the line was not fully reproduced, it received the score of 0. Both examiners repeated the scoring for all the gypsum specimens on different days. The worst score obtained from the 2 examiners was used to provide the final score.

The Wallace hardness micro-indentor machine is designed to measure hardness. The instrument has a Vickers diamond indenter with a two-stage application. Stage one involves lowering a weight of 10g and stage two involves lowering a weight of 300g. Following storage for 1 hour at ambient laboratory conditions (room temperature, 21-23°C, and humidity, 30-40%) the gypsum specimens were placed on the Wallace platform and the head of the instrument was lowered until the indenter just touched surface of the specimen. The minor load was then applied. The dial gauge was set to the zero reading. The secondary load was applied for a period of 30 seconds to give a hardness reading. Six indentation readings were made randomly for each specimen to minimise the possibility of finding porosity in one particular area of the specimen. Thus a total of 120 readings were made for each group. An average was calculated for each specimen. It should be noted that higher values from the Wallace machine are indicative of a softer surface.

Randomisation throughout the experiment was achieved using computer generated random numbers and allocation concealment was achieved using a numeric code identifying each cast. The Kappa statistic was used to assess inter- and intra-examiner agreement. Statistical analysis of line reproduction between groups was undertaken using Chi squared tests. A global test for differences between groups for mean hardness was performed using a 1-way ANOVA. Pairwise mean differences between groups were tested for statistical significance and a Bonferroni correction was applied to adjust for the effect of multiple testing. In all the cases significance was set at the 95% level ($P<0.05$).

RESULTS

Kappa scores indicated an excellent inter-examiner agreement with Kappa = 0.91 for the 50µm line. Kappa scores also revealed excellent intra-examiner agreement for both examiners with examiner 1 (SMAH) achieving Kappa = 0.94 and examiner 2 (CJT) achieving Kappa = 0.97.

Before disinfection all the alginate specimens were able to reproduce the 50µm line fully. After disinfection not all the alginate specimens reproduced the 50µm line. In all cases any line that was reproduced in the alginate impression

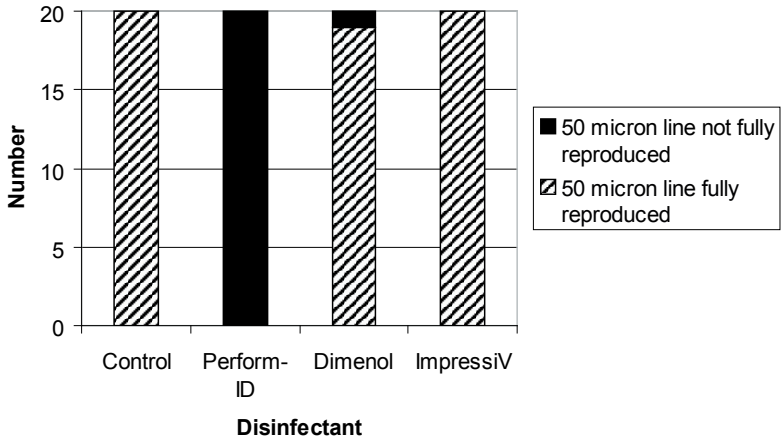

Figure 2. *Bar graph to show reproduction of the 50µm line on disinfected alginate impressions.*

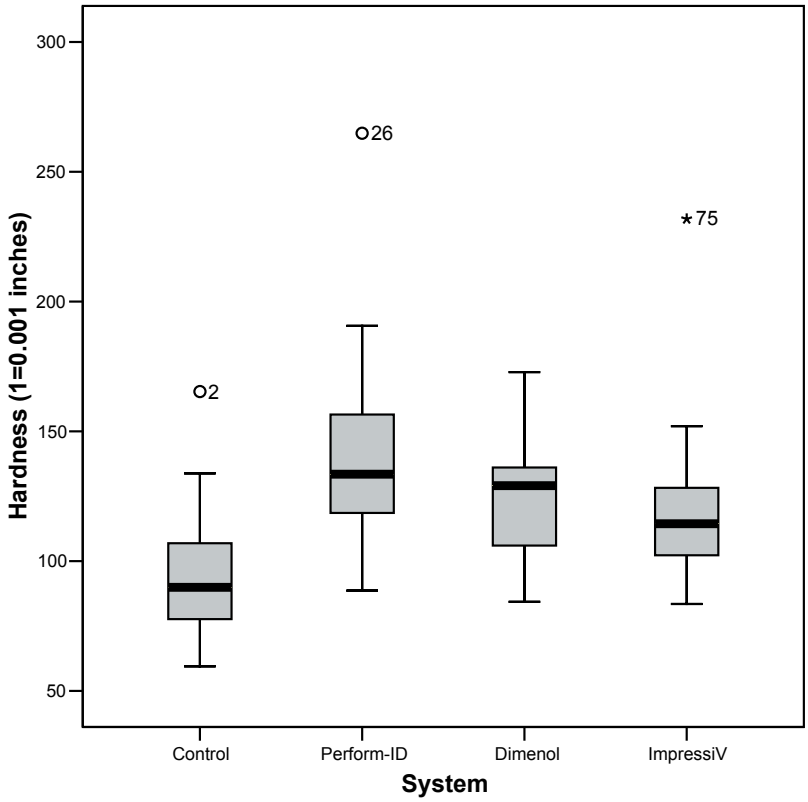

Figure 3. *Box plots of hardness results by disinfectant. Dark central bands represent median values; rectangles represent inter-quartile ranges; error bars represent 2.5 and 97.5 percentiles; points labelled 2, 26 and 75 are outliers. The higher the hardness value the softer the gypsum cast.*

material was also reproduced in the resultant gypsum.

Figure 2 shows the results of the surface detail reproduction scores obtained for each post-disinfection alginate group in the experiment. Chi squared statistical testing gave a P-value of <0.001.

Table I shows the mean hardness values obtained from the type III gypsum casts for each of the experimental groups with the accompanying 95% confidence intervals. Figure 3 shows a boxplot of the median scores and interquartile ranges obtained. A 1-way ANOVA (analysis of variance) produced P<0.001, indicating that a significant difference existed between the groups (Table II). Table III shows the results of multiple pairwise comparisons between the different groups employing a Bonferroni correction. There was a statistically significant difference (P<0.01) between the control group and the group treated with Perform and Dimenol. There were no statistically significant differences between the control group and ImpressiV or between the 3 disinfectant groups.

Table 1. Mean hardness values for the gypsum casts. Unit of measurement is 1= 0.001 inches.

	N	*Mean hardness*	*95% confidence interval for mean*	
Control	20	94.05	81.87	106.23
Perform	20	142.03	124.43	159.62
Dimenol	20	125.95	114.47	137.43
ImpressiV	20	119.39	104.54	134.25

Table 2. One-way ANOVA of hardness results obtained.

	Sum of squares	*df*	*Mean Square*	*F*	*Significance*
Between Groups	23875.48	3	7958.49	8.60	.000
Within Groups	70296.82	76	924.96		
Total	94172.30	79			

Table 3. Multiple comparisons of hardness results between the different systems using bonferroni correction.

Group (A)	(B)	*Mean Difference (A-B)*	*Significance*	*95% Confidence Interval*	
Control	Perform ID	47.98	<0.01*	21.92,	74.03
	Dimenol	31.90	0.01*	5.85,	57.95
	ImpressiV	25.34	0.06	-0.71,	51.40
Perform ID	Dimenol	16.08	0.59	-9.98,	42.13
	ImpressiV	22.63	0.13	-3.42,	48.68
Dimenol	ImpressiV	6.55	1.00	-19.50,	32.60

* The mean difference is significant at the .05 level.

DISCUSSION

The null hypothesis that disinfection will have no significant effect on surface detail reproduction of alginate impression or surface detail reproduction and hardness of resultant type III gypsum casts was rejected.

The manufacturers of Perform ID, ImpressiV and Dimenol clearly state that they are suitable for disinfection of alginate impressions. The active ingredients in Perform ID are potassium peroxymonosulphate, which is a powerful oxidising agent, and, thus bacteriocidal, and sodium benzoate, a sodium salt of benzoic acid which has antimicrobial features and controls bacterial/mould growth by interfering with their ability to generate energy. Dimenol and ImpressiV are both alcohol based disinfectants. The active ingredient in Dimenol is isopropyl alcohol and in ImpressiV, Propan-2-ol.

The results clearly showed that immersion in Perform ID was adversely affecting the reproduction of the 50µm line in all alginate specimens. This did not occur with the other two disinfectants or with the control. As the results of the surface reproduction test were identical for each alginate and type III gypsum pairing, it can be concluded that the effect of the Perform ID was on the alginate and not on the resultant compatibility of the alginate and type III gypsum. Furthermore, since the controls were immersed in water for the same period as those immersed in Perform ID, it can be concluded that it was the Perform ID and not simply the process of immersion that was adversely affecting the surface detail reproduction.

The Wallace Hardness Tester was chosen for its accuracy and efficiency in testing large sample sizes and is not prone to operator fatigue. Due to the potential for subsurface porosity within the type III gypsum six readings were taken. It can be seen when comparing the hardness of the control against the other three systems Perform ID and Dimenol made a significant difference to the surface hardness of the casts, making the surface significantly softer.

This study has shown that disinfectants can significantly affect the ability of an alginate impression to reproduce surface detail and also affect the hardness of subsequent casts. British Dental Association regulations recommend that immersion disinfection be used to treat impression materials[10]. It is important to note that the only disinfectant examined in this study which required immersion of the impression material, Perform ID, produced the only adverse effect on surface detail reproduction. Both Perform ID and the spray disinfectant Dimenol adversely affect surface hardness of the type III gypsum casts. The clinical implication of these findings is that the gypsum casts made from the impressions disinfected with Perform ID and Dimenol may not be accurate or hard enough to resist abrasion and this could lead to clinical error. Furthermore, since opposing casts are often poured from alginates, occlusal discrepancies may occur.

CONCLUSIONS

Within the limitations of this study the following conclusions can be drawn.

1. Disinfection with Perform ID according to manufacturer's instruction significantly affected surface detail of the alginate impression.
2. Spray disinfection with Dimenol and ImpressiV according to manufacturers instruction did not affect surface detail of the alginate impressions.
3. Disinfection of alginate with Perform ID and Dimenol significantly affected the hardness of resultant type III gypsum casts.
4. Disinfection with ImpressiV did not significantly affect the hardness of resultant type III gypsum casts.

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MANFACTURERS' DETAILS

- Alginoplast, Regular Set (Dental Alginate). Batch Number 1958624. Expiry Date 02/2006. Heraeus Kulzer, Berkshire, United Kingdom.
- Perform-ID (Immersion impression disinfectant). Batch Number 1059879. Expiry Date 12/2004. Schulke & Mayr GmbH, Germany.
- Dimenol (Spray impression disinfectant). Batch Number M2006. Expiry Date 06/2006. Septodont Ltd., France.
- ImpressiV (Spray impression disinfectant). Batch Number 9121. Expiry Date 09/2005. Alkapharm, UK Limited, Stafford, UK.
- Sterile water (used as water for mixing with Alginoplast). Batch Number 04C04B27. Expiry Date 02/2007. Baxter, S.A., 7860 Lessines.
- Type III Dental Stone, Crystacal, DPB Formula. Batch Number 0310703. Expiry Date 01/2007. Newark, Nottingham, United Kingdom.
- ISO 1563 Dental Test Suite. Ravenfield Designs Ltd., Russell St., Heywood, Lancashire, England.
- Polyethylene Sheets, 50mm x 50mm, 0.035mm thick. Dentsply, Herts, England.
- Water Bath, no. 67/3694/157. Baird and Tatlock (London) Limited. England.
- Mixing spatula and bowl. Dentsply (Ash Instruments), Herts, England.
- Vacuum Mixer, Multivac S. Degussa, Hanau, Germany.
- Weighing Scale. Waymaster, London, England.
- Vibrator, no. VVM413, Hz 50. Quale Dental, Worthing, England.
- Light Microscope, Wild M 5. Heerbrugg, Switzerland.
- Wallace Hardness Machine. H.W. Wallace & Co. Ltd., Croydon, England.

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