IN BRIEF

- Allows dental practitioners to recognise that immersion disinfection may have detrimental effects on the impression materials and gypsum casts poured from them.
- Details what categories of impression materials may be subject to these problems with immersion disinfection.
- Provides a working solution to the problem.

Effect of immersion disinfection with Perform-ID on alginate, an alginate alternative, an addition-cured silicone and resultant type III gypsum casts

S. Ahmad,[1] C. J. Tredwin,[2] M. Nesbit[3] and D. R. Moles[4]

Objective This study investigated the effect of a commonly used immersion disinfectant upon three different impression materials and any subsequent effects on the abrasion resistance, hardness and surface detail reproduction of gypsum casts.

Design A laboratory study.

Materials and methods Under standardised conditions a total of 120 impressions were made of a ruled test block using irreversible hydrocolloid (Alginoplast), an 'alginate alternative' addition-cure silicone (Position Penta) and a conventional addition-cure silicone (President). The impressions were examined for surface detail reproduction prior to and after disinfection with Perform-ID. The type III casts were evaluated for surface detail reproduction, surface hardness and abrasion resistance.

Results (1) None of the disinfected alginate specimens could reproduce the 50 µm line. (2) Casts produced from the disinfected alginate were significantly less hard than from disinfected Position Penta and President ($P < 0.001$). (3) Disinfection significantly affected the abrasion resistance of casts made from Position Penta ($P = 0.029$). (4) Disinfection did not significantly affect President or its subsequent casts ($P > 0.05$).

Conclusion If disinfecting with Perform-ID, the impression should be made with a conventional addition-cured silicone if good surface detail reproduction of the impression material and a hard and abrasion resistant type III gypsum cast are required.

[1]Graduate, [2*]Clinical Lecturer/Honorary Specialist Registrar in Restorative Dentistry, [3]Technical Instructor, Unit of Conservative Dentistry, UCL Eastman Dental Institute, University College London, 256 Grays Inn Road, London, WC1X 8LD; [4]Senior Clinical Lecturer in Health Sciences Research, UCL Eastman Dental Institute, University College London, 256 Grays Inn Road, London, WC1X 8LD
*Correspondence to: Mr Christopher Tredwin
Email: c.tredwin@eastman.ucl.ac.uk

Online article number E1
Refereed Paper – accepted 8 March 2006
DOI: 10.1038/bdj.2006.120

INTRODUCTION

Dental impressions become contaminated with the microorganisms from patients' saliva and blood, which can cross-infect gypsum casts poured against them.[1,2] The subsequent handling of impression materials following their removal from the oral cavity can create the potential for disease transmission.[3-6] 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.[7] Commonly used chemical disinfectants are alcohols, aldehydes, chlorine compounds, phenolics, biguanides, iodine compounds and quaternary ammonium compounds.[8] Three methods of cold disinfection exist: soaking, spraying and mixing with, or as a substitute for, water used to mix alginate.

As the necessity for disinfecting impressions has become apparent it has also become clear that the process itself should have no adverse impact on the dimensional accuracy and surface texture features of the impression material and resultant gypsum cast. 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.[4,9-19] In recent years, newer materials have been marketed as alginate alternatives, such as the addition-cured silicone Position Penta. There is little information regarding the effects of disinfection on these materials, or any effect it has on resultant gypsum casts. It is the purpose of this study is to examine the effect of a commonly used disinfectant (Perform-ID) on three different impression materials and the effect on the abrasion resistance, surface hardness and surface detail reproduction of the resultant type III gypsum casts.

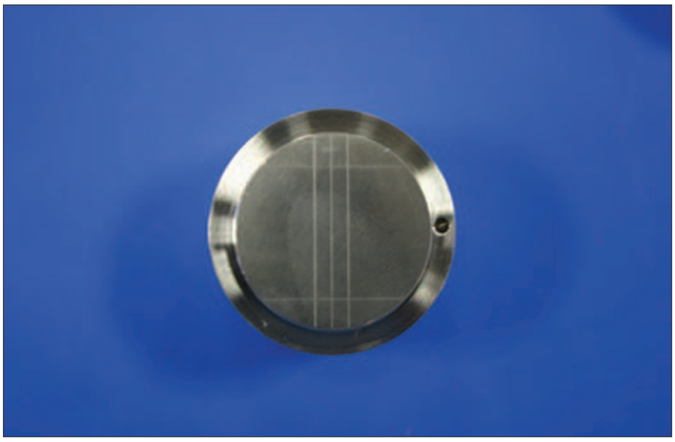

Fig. 1 The ISO test die used in study

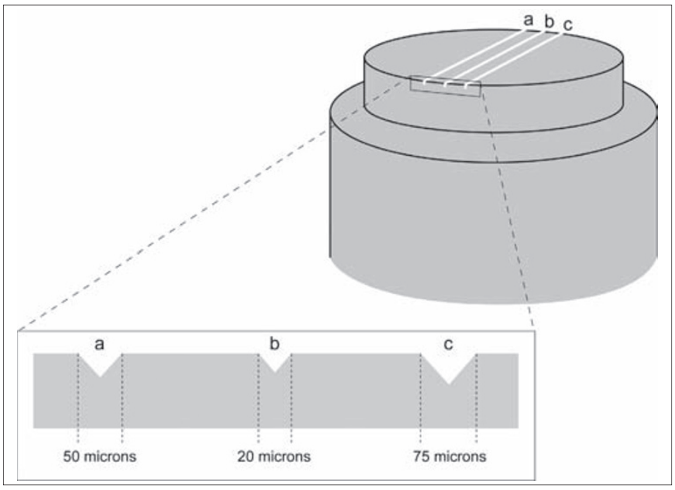

Fig. 2 Diagrammatic representation of ADA test die shown in Figure 1. Surface detail reproducibility of impressions and associated casts was measured via qualitative assessment of the reproduction of line 'a'

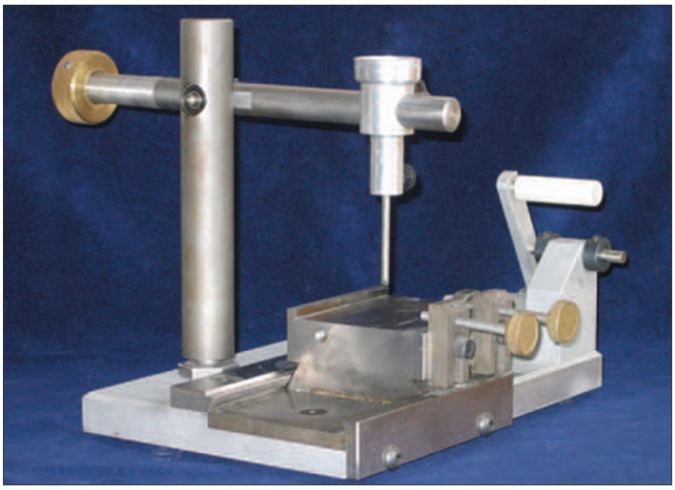

Fig. 3 Photograph of the abrasion device

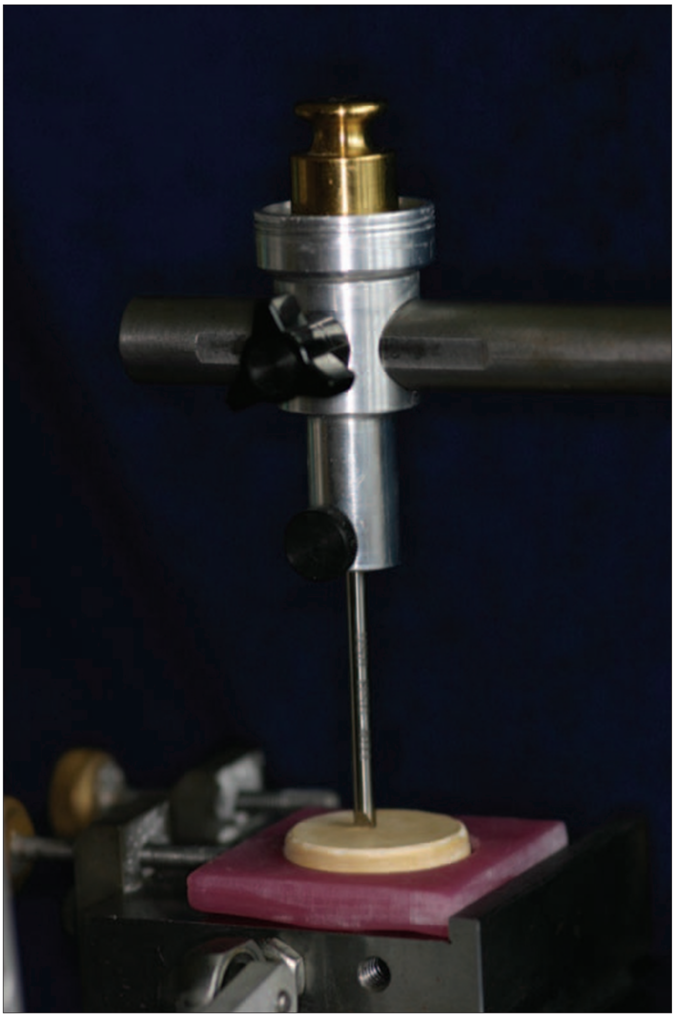

Fig. 4 Photograph of abrasion device with 50 g weight applied

Fig. 5 Photograph of specimen during abrasion testing

MATERIALS AND METHOD

Overview of preparation and disinfection of specimens

The experimental methodology was carried out in accordance with the tests described in ISO 1563 and 4823 specifications.[20,21] The ISO stainless steel test die (Ravensfield Design, Russell Street, Heywood, Lancashire, UK) inscribed with three horizontal and two vertical lines is shown in Figures 1 and 2. One scoop (9.0 g) of alginate powder (Alginoplast, fast set, Heraeuz Kulzer Limited, Bedfordshire) was mixed with 20 ml of distilled water (Baxter, UK) in a mixing bowl for a period of 60 seconds as per manufacturer's instructions. The test die was maintained in a water bath throughout the experiment (Baird and Tatlock, London) with the temperature set at 35 ± 1°C; this offered a heating rate of the test specimen comparable to the heating rate of impression material under oral conditions.[20,21] Forty impressions of the test die were made using

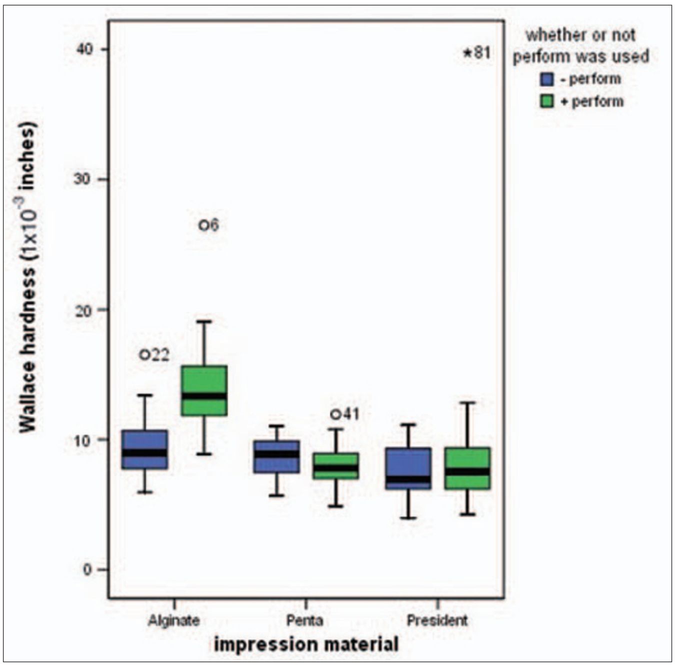

Fig. 6 Box plot showing the distribution of the Wallace hardness data for each impression material. Outliers are shown by numbers

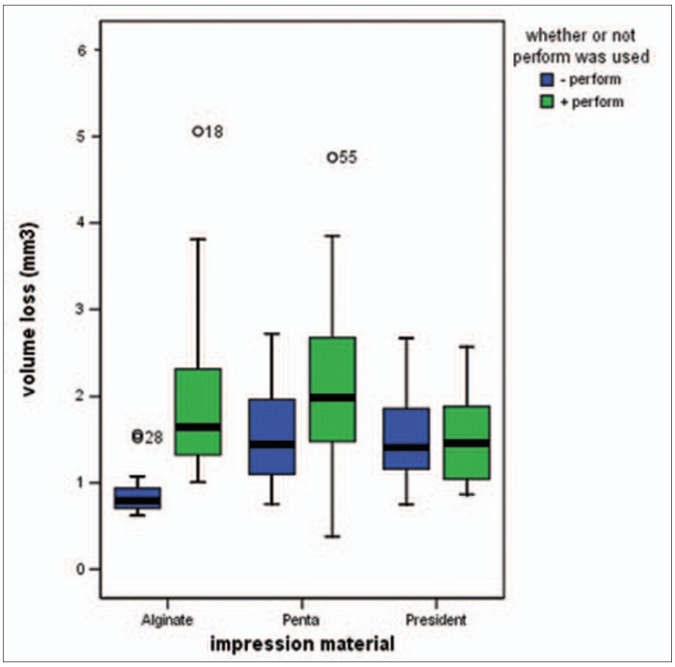

Fig. 8 Box plot displaying the distribution of volume loss data following abrasion testing for each impression material. Outliers are shown by numbers

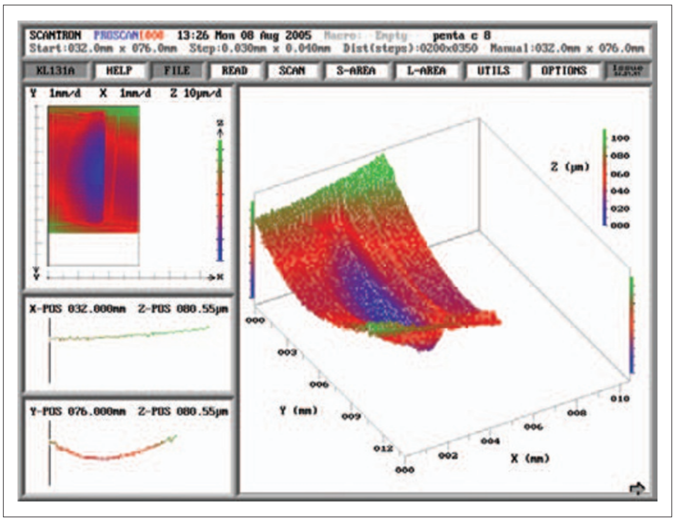

Fig. 7 Printout from the laser profilometer showing a typical wear scar from the type III gypsum casts

each of alginate, Position Penta (3M Espe AG Dental Products D-82229 Seefeld, Germany) and President (President PlusJet light body, Coltène Whaledent AG, Switzerland). Of the 40, 20 were used as controls and 20 in each set disinfected with Perform-ID (Schülke and Mayr GmbH, Germany). During disinfection, manufacturer instructions were followed with the impressions being rinsed with water, placed in the Perform-ID for 10 minutes and subsequently removed and rinsed with water. For the 20 controls in each group the impressions were rinsed with water, placed in a bath containing distilled water for 10 minutes, removed and again rinsed with water.

After the disinfection period, the impression materials were immediately poured with a type III gypsum product (Crystacal-D, BPB Formula, Newark, Nottingham, UK) using manufacturer's recommended water/powder ratios and vacuum mixing. All impression specimens were numbered and randomisation throughout the experiment was achieved using computer generated random numbers. Allocation concealment was achieved using a numeric code identifying each cast.

Surface detail reproduction of impressions

Immediately after setting, the impressions were separated from the test block and their surfaces assessed by two independent examiners under low angle illumination at x 12 magnification with a microscope (Wild M5, Heerbrugg, Switzerland) for reproduction of the lines from the test block surface. To comply with ISO specification number 1563 for detail reproduction, the alginate had to reproduce the full 25 mm length of the 50 µm wide line, whilst to comply with ISO specification 4823 the addition silicone had to reproduce the 25 mm length of the 20 µm wide line.[20,21] The results were recorded as either 1 for a line that was fully reproduced or 0 for a line that was not fully reproduced. After disinfection, surface detail reproduction was recorded again in accordance with the above criteria.

Surface detail reproduction of stone casts

According to ISO specification 1563, stone casts made from alginate have to reproduce the 50 µm wide line, whilst to satisfy specification 4823 casts poured against addition-cured silicones must reproduce the 50 µm wide line.[20,21] All gypsum specimens were examined by two independent examiners under low angle illumination at x 12 magnification with a microscope using the same scoring criteria for the impressions. If disagreement occurred, the worse score was recorded. Each examiner then scored the specimens randomly on two separate occasions without reference to previous readings.

Surface hardness of the gypsum casts

Each gypsum specimen was evaluated for surface hardness using the Wallace Hardness Machine (H. W. Wallace and Co Ltd, England). This machine is designed to measure accurately the depth of indentation in terms of linear depth measurement into the gypsum specimen in inches. The instrument has a

Vickers diamond indenter with a two-stage application. Stage one involves lowering a weight of 10 g and stage two lowering a weight of 300 g, this occurs over a 45 second period.

Following pouring, the specimens were stored for one hour at ambient laboratory conditions (room temperature, 21-23°C, and humidity, 30-40%). Subsequently the specimens were placed on the Wallace platform and six indentation readings were made randomly for each specimen. The six readings minimised the possibility of finding porosity in one particular area of the specimen and allowed an average to be calculated.

Abrasion testing of the gypsum casts

Abrasion testing was carried out immediately following the surface hardness test using the abrasion testing device shown in Figures 3-5 (University of Iowa, Iowa City, United States of America). The specimens were assessed using a spirit level to ensure that they were completely flat. Following securing of the specimens in a jig, the stylus was adjusted such that the position of the chisel was perpendicular to the surface. Following placement of a 50 g weight, the reciprocating table was driven manually 80 times over a 10 mm length of the specimen. The wear scar produced was analysed using a laser profilometer (Proscan 1000, Scantron Industrial Products Ltd, Monarch Centre, Venture Way, Taunton, Somerset, United Kingdom) and the volume of the defect subsequently calculated.

Statistical methods

The Kappa statistic was used to assess inter- and intra-examiner agreement. Statistical analysis of line reproduction between groups was undertaken using Chi square tests. For both the abrasion resistance and surface hardness tests a two-way analysis of variance (ANOVA) was performed. If significant differences were found, pairwise comparisons, adjusted using the Bonferroni correction, were applied. In order to assess if there was any correlation between abrasion resistance and surface hardness, Spearman's rank correlation (a non parametric test) was used. The significance level was set at 5% throughout.

RESULTS

Kappa scores indicated an excellent inter-examiner agreement with Kappa = 0.91 for all impression material and gypsum surface detail reproduction recordings made. Kappa scores also revealed excellent intra-examiner agreement for both examiners with examiner 1 achieving Kappa = 0.94 and examiner 2 achieving Kappa = 0.97.

Before disinfection, all the alginate specimens were able to reproduce the 50 µm line fully. After disinfection none of the alginate specimens reproduced the 50 µm line. The loss of detail seen after disinfection was reflected in the type III gypsum casts without additional loss of detail. All of the Position Penta and President addition-cure silicone impressions were able to fully reproduce the 20 µm lines both pre and post disinfection. All the lines were also fully reproduced in the subsequent type III gypsum stone casts.

Figure 6 shows a box plot of the distribution of Wallace hardness data for the type III gypsum casts for each impression material. The box plot shows that the data are approximately normally distributed with four outliers. Table 1 shows the results of the two-way ANOVA obtained for the Wallace hardness data and shows that the impression material was significant in determining hardness ($P < 0.05$), Perform-ID was significant in determining the hardness ($P < 0.05$) and the impression material and Perform-ID interaction was significant in determining hardness ($P < 0.05$). Table 2 shows pairwise comparisons of mean hardness for the gypsum casts poured from each impression material and shows that the mean hardness for the gypsum casts poured from alginate is significantly less than both Postion Penta ($P < 0.05$) and President ($P < 0.05$). There is no evidence of a difference in mean hardness of the gypsum casts between Position Penta and President ($P > 0.05$). Table 3 shows pairwise comparison of hardness comparing the Perform-ID treated group with the control and shows that when Perform-ID is used there is a statistically significant mean reduction in hardness ($P < 0.05$). Table 4 shows the mean hardness for each subgroup.

Table 1 Two way ANOVA for hardness data

Source	Type III sum of squares	Degrees of freedom	Mean square	F	Sig.
Corrected model	579.86	5	115.97	8.11	P <0.001
Intercept	10913.83	1	10913.83	763.46	P <0.001
Impression material	308.57	2	154.29	10.79	P <0.001
Perform-ID	122.35	1	122.35	8.60	P = 0.004
Impression material and Perform-ID.	148.93	2	74.47	5.21	P = 0.007
Error	1629.68	114	14.30		
Total	13123.34	120			
Corrected total	2209.51	119			

Table 2 Pairwise comparisons of mean hardness of the casts poured from each impression material

Impression material	Impression material	Mean difference	Standard error	Sig.	95% confidence interval for difference	
A	B	A-B			Lower bound	Upper bound
Alginate	Penta	3.45	0.85	P <0.001	1.40	5.51
Alginate	President	3.35	0.85	P <0.001	1.30	5.41
Penta	President	-0.10	0.85	P = 1.000	-2.16	1.95

Table 3 Pairwise comparisons of hardness comparing the Perform treated group with the control

Perform-ID usage	Perform-ID usage	Mean difference	Standard error	Sig.	95% confidence interval for difference	
A	B	A-B			Lower bound	Upper bound
With Perform	No Perform	2.019	0.690	P = 0.004	0.65	3.39

Table 4 Mean hardness for each subgroup

Impression material	Perform-ID usage	Mean	Standard error	95% confidence interval	
				Lower bound	Upper bound
Alginate	No Perform	9.41	0.85	7.73	11.08
	With Perform	14.20	0.85	12.53	15.86
Penta	No Perform	8.68	0.85	7.00	10.36
	With Perform	8.02	0.85	6.35	9.70
President	No Perform	7.49	0.85	5.82	9.20
	With Perform	9.41	0.85	7.74	11.10

Table 5 Two way ANOVA summary for volume loss after abrasion testing

Source	Type III sum of squares	Degrees of freedom	Mean square	F	Sig.
Corrected model	20.31	5	4.06	8.03	P <0.001
Intercept	309.26	1	309.26	611.16	P <0.001
Impression material	3.83	2	1.92	3.79	P = 0.026
Perform-ID	10.28	1	10.27	20.30	P <0.001
Impression material and Perform-ID	6.20	2	3.10	6.13	P <0.003
Error (residual)	57.69	114	0.50		
Total	387.25	120			
Corrected total	77.99	119			

Table 6 Mean volume loss for each subgroup

Impression material	Perform-ID usage	Mean	Standard error	95% confidence interval	
				Lower bound	Upper bound
Alginate	No Perform	0.87	0.16	0.56	1.19
	With Perform	1.99	0.16	1.68	2.31
Penta	No Perform	1.54	0.16	1.22	1.85
	With Perform	2.16	0.16	1.85	2.48
President	No Perform	1.53	0.16	1.21	1.84
	With Perform	1.54	0.16	1.22	1.85

Table 7 Pairwise comparisons of mean volume loss of the casts poured from each impression material

Impression material	Impression material	Mean difference	Standard error	Sig.	95% confidence interval for difference	
A	B	(A-B)			Lower bound	Upper bound
Alginate	Penta	-0.42	0.16	P = 0.029	-0.81	-0.03
Alginate	President	-0.10	0.16	P = 1.000	-0.49	0.29
Penta	President	0.32	0.16	P = 0.143	-0.07	0.71

Table 8 Pairwise comparisons of mean volume loss, comparing the Perform treated group with the control

Perform-ID usage	Perform-ID usage	Mean difference	Standard error	Sig.	95% confidence interval for difference	
A	B	(A-B)			Lower bound	Upper bound
With Perform	No Perform	0.59	0.13	P <0.001	0.33	0.84

A typical printout from the laser profilometer showing a wear scar is shown in Figure 7. Figure 8 shows a box plot of the distribution of volume loss data obtained for the type III gypsum casts obtained for each impression material. The box plot shows that the data are approximately normally distributed with three outliers. Table 5 shows the results of the two-way ANOVA obtained for the volume loss data and shows that the impression material was significant in determining the volume loss ($P < 0.05$), the Perform-ID was highly significant in determining the volume loss ($P < 0.05$) and the impression material and Perform-ID combinations were significant in determining volume loss ($P < 0.05$). Table 6 shows the mean volume loss for each subgroup. Table 7 shows pairwise comparisons of mean volume loss for each impression material and shows that the mean volume loss for alginate is significantly less than the Position Penta ($P < 0.05$), but there was no significant difference in mean volume loss between alginate and President ($P > 0.05$) or Position Penta and President ($P > 0.05$). Table 8 shows pairwise comparisons of mean volume loss, comparing the Perform-ID group with the control and reveals that when Perform-ID is used there is a significant increase in volume loss ($P < 0.05$). Spearman's rank correlation coefficient was calculated to determine if there was any correlation between volume loss and hardness and revealed a value of 0.301.

DISCUSSION

Perform-ID disinfectant was chosen for use in this study as it is a commonly used disinfectant. The manufacturer's instructions state that Perform-ID is suitable for disinfection of alginate and addition-cured silicone 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.

ISO 1563 specification states that the alginate impression and resultant cast shall be able to reproduce the 50 µm line without interruption when testing for reproduction of detail and compatibility with gypsum products, while ISO 4823 specification states that elastomeric impression materials should be able to reproduce the 20 µm line and the resultant gypsum cast the 50 µm line.[20,21] The results clearly showed that immersion in Perform-ID adversely affected the reproduction of the 50 µm line in all alginate specimens. This did not occur with either President or Position Penta. As the controls were immersed in water for the same period as those immersed in Perform-ID, it can be proposed that it is the Perform-ID and not simply the process of immersion that is adversely affecting the surface detail reproduction.

The Wallace Hardness Tester was chosen for its accuracy and efficiency in testing large sample sizes. Due to the potential for subsurface porosity within the type III gypsum, six readings were taken. It can be seen that Perform-ID disinfection significantly affected the hardness of resultant type III gypsum casts poured from alginate, making the surface significantly softer, but not those from Position Penta or President. It can be postulated that because of the nature of alginate, it retains and passes in to the gypsum some of the Perform-ID and this is able to affect the surface hardness of the gypsum.

There is currently no standardised abrasion device for dental materials. The device used in this study was a custom tool which had been previously reported to be a satisfactory method for determining abrasion in gypsum.[22] The laser profilometer used in this study – Proscan 1000 – is a non-contact laser scanning system, which employs laser triangulation technology to perform 3D surface profile measurements. The abrasion results found in this study revealed that the disinfected gypsum casts produced from alginate were significantly more abrasion resistant than those produced from Position Penta. Gypsum casts poured from President were not significantly different to either of the other two materials used. Position Penta has been marketed as an alginate alternative, however in terms of abrasion resistance when combined with Perform-ID it behaved unlike President, and indeed performed significantly worse than alginate. This is of concern and requires further investigation.

The Spearmans rank correlation of 0.301 showed no correlation between abrasion resistance and surface hardness and this conforms with current understanding in this area.[23]

This study has shown that disinfection with Perform-ID can significantly affect the ability of an alginate impression to reproduce surface detail and also affect the hardness of subsequent casts. It has also shown that disinfection with Perform-ID significantly affected the abrasion resistance of a marketed alginate alternative addition-cured silicone – Position Penta. British Dental Association regulations recommend that immersion disinfection be used to treat impression materials.[24] Perform-ID is a commonly used immersion disinfectant and the findings of this study are of concern.

The clinical implication of these findings is that gypsum casts made from alginate impressions disinfected with Perform-ID may have poor surface detail reproduction and be comparatively softened. This could have the potential to lead to clinical error if the gypsum cast is required to be accurate. If using Perform-ID disinfection, use of the marketed 'alginate alternative' Position Penta presents its own problem of producing gypsum casts which have a comparatively lower abrasion resistance. Perform-ID disinfection had no effect on the addition-cured silicone used in this study, President, nor its resultant gypsum casts. If Perform-ID disinfection is being utilised and a gypsum cast with good surface detail reproduction, hardness and abrasion resistance is required, then the impression should be made with a traditional addition-cured silicone.

CONCLUSIONS

Within the limitations of the techniques employed in this laboratory study it is possible to draw the following conclusions:

1. Perform-ID immersion disinfection adversely affected the surface detail reproduction of alginate.
2. Perform-ID immersion disinfection adversely affected the surface hardness of type III gypsum casts poured from alginate.
3. Perform-ID immersion disinfection adversely affected the abrasion resistance of type III gypsum casts produced from a marketed 'alginate alternative' addition-cured silicone, Position Penta.
4. Perform-ID immersion disinfection did not have any detrimental effect on President addition-cured silicone nor resultant type III gypsum casts made from it.

The authors would like to express their thanks to Dr Terry Lindquist for loaning the abrasion testing device used in this study.

1. Chau V B, Saunders T R, Pimsler M, Elfring D R. In depth disinfection of acrylic resins. *J Prosthet Dent* 1995; **74:** 309-313.
2. Leung R L, Schonfield S E. Gypsum casts as a potential source of microbial cross-contamination. *J Prosthet Dent* 1983; **49:** 210-211.
3. Schwartz R S, Bradley D V Jr, Hilton T J, Kruse S K. Immersion disinfection of irreversible hydrocolloid impressions, Part 1: microbiology. *Int J Prosthodont* 1994; **7:** 418-423.
4. Owen C P, Goolam R. Disinfection of impression materials to prevent viral cross contamination: a review and a protocol. *Int J Prosthodont* 1993; **6:** 480-494.
5. Runnells R R. An overview of infection control in dental practice. *J Prosthet Dent* 1988; **59:** 625-629.
6. Davids G R, Porra M. The need for post vaccination serology and the timing of booster vaccinations against hepatitis B in dental health care workers. *Aust Dent J* 1994; **39:** 238-241.
7. Connor C. Cross-contamination control in prosthodontic practice. *Int J Prosthodont* 1991; **4:** 337-344.
8. Kwok W M, Ralph W J. The use of chemical disinfectants in dental prosthetics. *Aust Dent J* 1984; **29:** 180-183.
9. Boden J, Likeman P, Clark R. Some effects of disinfecting solutions on the properties of alginate impression material and dental stone. *Eur J Prosthodont Restor Dent* 2001; **9:** 131-135.
10. 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:** 255-262.
11. Herrera S P, Merchant V A. Dimensional stability of dental impressions after immersion disinfection. *J Am Dent Assoc* 1986; **113:** 419-422.
12. Durr D P, Novak E V. Dimensional stability of alginate impressions immersed in disinfecting solutions. *J Dent Child* 1987; **54:** 45-48.
13. Tullner J B, Commette J A, Moon P C. Linear dimensional changes in dental impression after immersion in disinfectant solutions. *J Prosthet Dent* 1988; **60:** 725-727.
14. Peutzfeldt A, Asmussen E. Effect of disinfection solutions on surface texture of alginate and elastomeric impressions. *Scand J Dent Res* 1989; **96:** 74-81.
15. Rueggeberg F A, Beall E, Kelly M T, Schuster G S. Sodium hypochlorite disinfection of irreversible hydrocolloid impression material. *J Prosthet Dent* 1992; **67:** 628-631.
16. Tan H K, Wolfaardt J F, Hooper P M, Busby B. Effects of disinfecting irreversible hydrocolloid impressions on the resultant gypsum casts: part I – surface quality. *J Prosthet Dent* 1993; **69:** 250-257.
17. Vandewalle K S, Charlton D G, Reagan S E, Koeppen R G. Immersion disinfection of irreversible hydrocolloid impressions with sodium hypochlorite. Part II: effect on gypsum. *Int J Prosthodont* 1994; **7:** 317-322.
18. Johnson G H, Chellis K D, Gordon G E, Lepe X. Dimensional stability and detail reproduction of irreversible hydrocolloid and elastomeric impressions disinfected by immersion. *J Prosthet Dent* 1998; **79:** 446-453.
19. Taylor R L, Wright P S, 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:** 103-110.
20. International Standards Organisation. *Specification for alginate impression material 1563.* ISO, 1990.
21. International Standards Organisation. *Specification for gypsum products 6873.* ISO, 2000.
22. Lindquist T J, Stanford C M. Development and application of a new abrasion testing device. *J Prosthet Dent* 2000; **84:** 635-641.
23. Peyton F A, Leibold J P, Ridgley G V. Surface hardness, compressive strength and abrasion resistance of indirect die stones. *J Prosthet Dent* 1952; **5:** 381-389.
24. British Dental Association. *Advice sheet A12.* London: BDA, 2003.