Effects of a Chemical Disinfectant on the Physical Properties of Dental Stones

B. Daniel Hall, DDS[a]
Carlos A. Muñoz-Viveros, DDS, MSD[b]
W. Patrick Naylor, DDS, MPH, MS[c]
Jenny Sy, DDS, MSD[a]

Purpose: This study compared the effects of an antimicrobial agent (Asepto-Sol) on the physical properties of types III, IV, and V gypsum casts made from two types of impression materials. **Materials and Methods:** Selected physical properties of five gypsum-based dental stones (Prima-Rock, Ortho Stone, New Fujirock, Die-Keen, Microstone) and two resin-based dental stones (Resin-Rock, Instone) were evaluated using an addition silicone impression material (Reprosil) and an irreversible hydrocolloid (Jeltrate Plus). In group 1, Asepto-Sol solution replaced water as the gauging liquid for the seven dental stones. The mixed gypsum was poured directly onto impressions of two master dies using two impression materials. In group 2, impressions made with both impression materials were sprayed with the Asepto-Sol solution, left for 10 minutes, rinsed for 30 seconds with tap water, and poured with each dental stone mixed with deionized water. In group 3 (control), the gypsums were mixed with deionized water and the mixed stone was poured directly into impressions, with no exposure to Asepto-Sol. The physical properties evaluated for the gypsum specimens were linear dimensional change, detail reproduction, Knoop hardness, and transverse strength. **Results:** The linear dimensional stability, detail reproduction, and transverse strength tests were relatively unaffected by the use of Asepto-Sol, with few exceptions. Detail reproduction appeared to be least affected by Asepto-Sol, and changes in Knoop hardness were noted but results differed among the seven dental stones. However, New Fujirock was not ideally matched with Jeltrate Plus, and no stone specimens could be produced. **Conclusion:** Whether mixed with the gypsum powder or sprayed on impressions, Asepto-Sol solution did not adversely affect the physical properties of the dental stones tested. *Int J Prosthodont 2004;17:65–71.*

There is a growing body of research in the area of dental infection control. This trend is certain to continue, particularly as new materials and techniques are introduced to enhance existing infection-control procedures and reduce potential sources of cross-contamination. Studies have documented the transfer of microorganisms from dental impressions to gypsum casts.[1–3] Thus, measures that enhance the effectiveness of the barrier system merit scrutiny. Impression making is one widely used procedure where clinicians must balance the requirement to maintain an intact barrier system with the need to produce accurate dental casts.

The American Dental Association and the Centers for Disease Control recommend the disinfection of dental impressions and gypsum casts.[4,5] Comparisons of the efficacy of immersion versus spray disinfection using different disinfectants and exposure times have been reported, with varied results.[6–14] Researchers have assessed the effectiveness of adding a chemical disinfectant to the gypsum mix itself.[15,16] Ivanovski et al[15] found 2% glutaraldehyde to be the most effective disinfectant with the least adverse effects on the physical properties of a cast. However, concerns for the toxicity of glutaraldehyde preclude its use on a daily basis. Although providone-iodine may be an able substitute, it can decrease the compressive strength of

[a]*Associate Professor, Department of Restorative Dentistry, Loma Linda University School of Dentistry, California.*
[b]*Professor and Director, Center for Dental Research, Loma Linda University School of Dentistry, California.*
[c]*Adjunct Professor, Department of Restorative Dentistry, Loma Linda University School of Dentistry, California.*

***Correspondence to:** Dr Carlos A. Muñoz-Viveros, Center for Dental Research, Loma Linda University School of Dentistry, Loma Linda, California 92350. Fax: + (909) 558-0270. e-mail: cmunoz@sd.llu.edu.*

Table 1 Materials and Manufacturers Used

Material/product	Type
Dental stone	
Prima-Rock, Whip Mix	Type IV
Resin-Rock, Whip Mix	Type IV
Microstone, Whip Mix	Type III
Orthodontic Stone, Whip Mix	Type III
Die-Keen, Modern Materials Miles	Type V
Instone, Leach & Dillon	Type IV
New Fujirock, GC	Type IV
Impression material	
Reprosil Regular Body, Dentsply/Caulk	
Jeltrate Plus Regular Set, Dentsply/Caulk	
Chemical disinfectant solution	
Asepto-Sol, Asepto Systems	0.25% chloramine T

gypsum.[15] Breault et al[16] reported that the addition of a 5.25% solution of sodium hypochlorite actually increases the compressive strength of gypsum and decreases the setting time, but leaves other physical properties unchanged.

Reports describe incorporating a chemical disinfectant in impression materials, as well as using different chemical disinfectants for spray and immersion disinfection for both impressions and casts.[17–21] Investigators have even evaluated dental stones containing a chemical disinfectant added to the gypsum powder during manufacturing.[22,23] Aside from disinfecting dental impressions, no one approach has emerged as the most effective method of preventing possible cross-contamination when handling dental impressions and casts.

The present investigation was undertaken to evaluate the effects of an antimicrobial agent, Asepto-Sol, on the physical properties of seven dental stones representing three different types of gypsum products using two types of impression materials following two disinfection protocols. The hypothesis of the study was that the Asepto-Sol disinfectant solution would have no effect on the physical properties of the two dental impression materials and the seven gypsum products.

Materials and Methods

Impression and Die Materials

Seven gypsum products representing type III dental stones and type IV and V die stones were chosen for evaluation with a polyvinyl siloxane (PVS) and an irreversible hydrocolloid (alginate) impression material (Table 1). Two categories of gypsums were represented: 100% gypsum and the newer, resin-gypsum die materials containing a resin filler.

The disinfectant was prepared according to the manufacturer's instructions by dissolving four 4.5-g Asepto-Sol tablets in 1 gal deionized water and allowing the mixture to stand overnight prior to use. The resulting solution contained 0.25% chloramine-T. Impressions were made of a round stainless steel master die with engraved lines to measure linear dimensional change and detail reproduction (Fig 1). A stainless steel bar (40 mm long, 6 mm wide, 6 mm high) served as the master die for the Knoop hardness and transverse strength tests.

Test Groups

In group 1, gypsum specimens were produced, with Asepto-Sol solution serving as the gauging liquid for the stone powders, following the manufacturers' recommended water:powder ratio. The PVS and irreversible hydrocolloid impression materials were mixed conventionally, with deionized water serving as the irreversible hydrocolloid gauging liquid. The two master metal dies were impressed and poured in stone as described for each of the following four test procedures.

In group 2, the PVS and irreversible hydrocolloid impression materials were mixed as in group 1, and impressions were made of the two master dies. Each impression was sprayed with the same concentration of Asepto-Sol solution used for the gauging liquid in group 1. These impressions were sealed in a zippered plastic bag. After a 10-minute contact time, the impressions were removed from the plastic bag, rinsed for 30 seconds under gentle running tap water, and poured with the different dental stones. The gypsum specimens were separated from the impressions 1 hour after the start of mixing.

For group 3 (controls), the two impression materials were mixed as in groups 1 and 2. Impressions were made of the master dies and poured in each of the seven dental stones using deionized water and the recommended powder:liquid ratio. Neither the impression materials nor the dental stones were exposed to Asepto-Sol, and the resulting specimens served as the controls.

Seventy gypsum specimens were produced for each of the following tests: linear dimensional change, Knoop hardness, detail reproduction, and transverse strength. The tests were conducted in accordance with modified American National Standards Institute/American Dental Association (ANSI/ADA) specifications No. 19 and No. 18 test methodology.

Testing Procedures

A specially fabricated round, stainless steel master die with reference marks engraved at each end of the top surface was used for the linear dimensional change

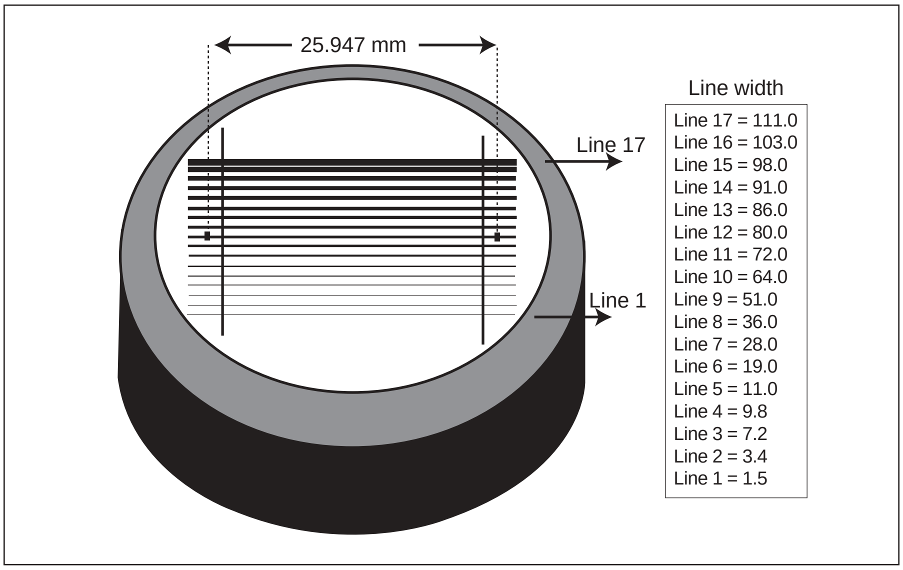

Fig 1 Test surface of the master die used for the linear dimensional change and detail reproduction tests.

and detail reproduction tests (Fig 1). Two indentations approximately 3 µm long and positioned at right angles to each other formed a reference point at their intersection. The distance between the outer marks on the master metal die measured 25.947 mm. Ten PVS and 10 irreversible hydrocolloid impressions of the metal die were made at room temperature (23 ± 1°C) for each of the seven gypsum products. The dental stones were mixed, poured, and stored according to the criteria established for the three groups.

The distance between the outer reference points on the test surface was measured on the stone casts 2 hours after the start of mixing. This time delay was chosen to ensure the different stones had set completely and the surface was dry. Five measurements were made per specimen and averaged by one investigator. The means and standard deviations (SD) for the percent change in length, as compared to the length of the master mold (25.947 mm), were calculated and recorded.

The specimens produced for the dimensional change test were also used to assess detail reproduction. The master die had 17 lines, 30 mm long, that ran parallel to one another and were at right angles to the die's long axis (Fig 1). The width of the scribed lines ranged from 1.5 µm (line 1) to 111.0 µm (line 17). After making the linear dimensional change measurements, one investigator scored the specimens for detail reproduction. If 75% or more of a length was reproduced, the stone was scored as being able to reproduce that line. Scoring was conducted under 10× magnification using a stereo measuring microscope (Mitutoya) with a traveling stage and a resolution of 1 µm.

A stainless steel bar (40 mm long, 6 mm wide, 6 mm high) served as the master die for the Knoop hardness and transverse strength tests. Two PVS impressions were made of the master die for each dental stone–impression material combination and poured five times to produce 10 dies for the hardness test. Ten individual irreversible hydrocolloid impressions had to be made and poured for each die stone–impression material combination. Testing was conducted 24 hours after the specimens were poured, and all specimens were maintained at room temperature. A Knoop hardness tester (M-400-H1, Leco) was used with a 20-second dwell time and a 500-g load. Five indentations were made on the test surface of every cast, and the mean and SD were calculated for each group of 10 specimens.

Following the Knoop hardness test and 48 hours after pouring the dental stones, the transverse strength test was conducted using a three-point bending test. Each gypsum replica of the steel bar was prepared to a uniform thickness verified with measuring calipers. The specimens were placed in an Instron universal testing machine (model 1125) and loaded at a crosshead speed of 0.1 mm/min until fracture occurred. The transverse strength was calculated using the following formula:

$$S = 3WL/2bd^2$$

where S = transverse strength; W = maximum load before fracture; L = distance between the supports; b = width of specimen; and d = thickness of specimen.

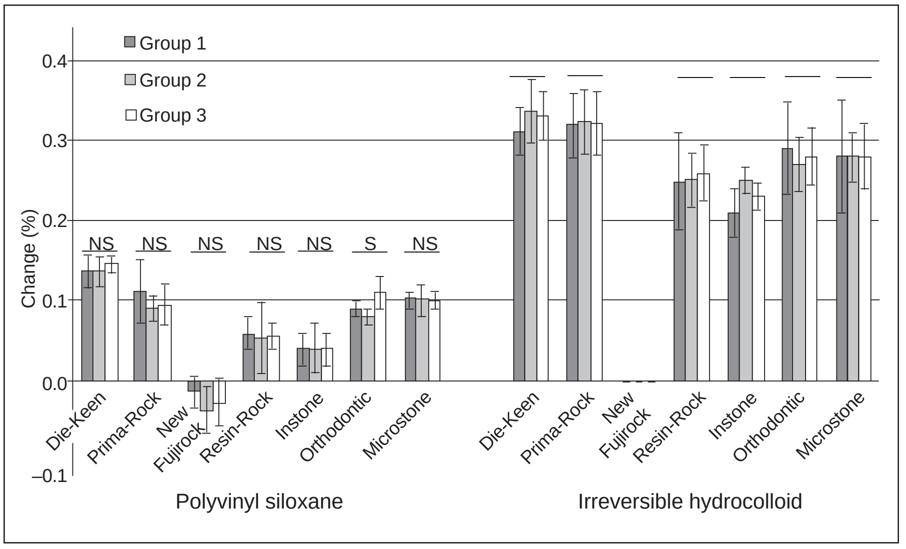

Fig 2 Linear dimensional change values for the three test groups. *NS* = not significant ($P >$ .05); *S* = significant ($P <$ .001).

Table 2 Detail Reproduction (Mean Line Width in µm; n = 10)

Group	Die-Keen	Prima-Rock	New Fujirock	Instone	Resin-Rock	Orthodontic Stone	Microstone
Polyvinyl siloxane							
Group 1	11	11	11	11	19	11	19
Group 2	11	11	11	11	19	19	19
Group 3	7	7	11	11	11	11	11
Irreversible hydrocolloid							
Group 1	19	19	NA	28	28	28	28
Group 2	28	28	NA	28	28	28	28
Group 3	19	28	NA	28	28	28	28

Statistical Analysis

For the linear dimensional change, transverse strength, and hardness tests, a one-way analysis of variance (ANOVA) was performed. If significant differences were found, the Student-Newman-Keuls multiple comparison test was applied to identify those differences. Comparisons were made between the two impression materials among the three groups (P = .05). For the detail reproduction test, a one-way ANOVA on ranks was used to determine if one of the gypsums had better detail reproduction with the two impression materials, and if there were differences among the three test groups (P = .05).

Results

Linear Dimensional Change

There were no statistical differences in the linear dimensional change for six of the seven stone dies produced from the PVS impression material in any of the three groups (Fig 2). The exception was Orthodontic Stone, where groups 1 and 2 had significantly less linear dimensional change than their control group. In contrast, with Reprosil, the New Fujirock casts produced for all three groups actually underwent a negative linear dimensional change (contraction).

Specimens produced from the combination of New Fujirock and Jeltrate Plus had less than ideal surface quality, so linear dimensional change could not be measured (Fig 2). For the remaining six dental stones, the amount of linear dimensional change among the three groups was not significant.

Detail Reproduction

In this test, the stone specimens for groups 1 and 2 made from Reprosil impressions reproduced the 11- and 19-µm-wide lines (Table 2). Gypsum casts produced for the Die-Keen and Prima-Rock controls (group 3), however, were able to reproduce detail as fine as the 7-µm-wide line. When Asepto-Sol was used as the gypsum gauging liquid (group 1) or

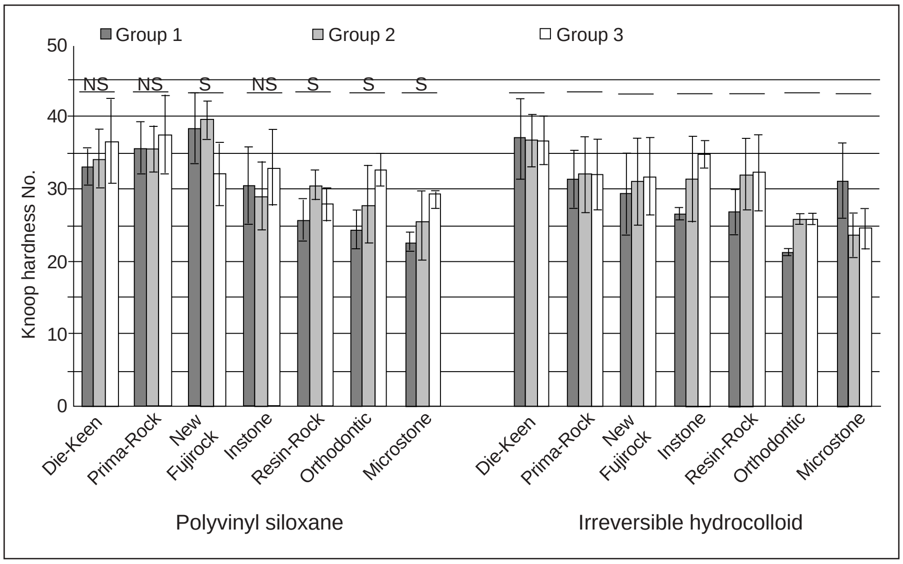

Fig 3 Knoop hardness numbers for the three test groups. *NS* = not significant ($P > .05$); *S* = significant ($P < .001$).

sprayed on the PVS impressions, fine detail reproduction was limited to the 11-µm-wide line.

When poured against the Jeltrate Plus irreversible hydrocolloid impressions, only Die-Keen and Prima-Rock replicated the 19-µm-wide line (group 1). All the other materials reproduced the 28-µm-wide line (Table 2). However, none of the observed differences were statistically significant. As mentioned previously, the New Fujirock specimens derived from Jeltrate Plus lacked the required surface quality to perform the detail reproduction test (Table 2).

Knoop Hardness

Changes in the Knoop hardness number (KHN) of four dental stones produced from Reprosil were statistically different ($P < .01$), but the actual outcomes varied (Fig 3). For New Fujirock, the mean KHN increased significantly for both test groups (compared to the controls) but decreased significantly for Orthodontic Stone and Microstone. With Resin-Rock, the mean KHN for group 2 specimens was significantly higher than that of groups 1 and 3.

When Jeltrate Plus was used as the impression material, only the Instone, Resin-Rock, and Microstone specimens demonstrated any significant change in surface hardness ($P < .05$; Fig 3). For Instone, the two test groups had significantly lower mean KHN values compared to the controls. The surface hardness of Resin-Rock declined significantly for group 1 but not group 2. With Microstone, the results were mixed, with an insignificant decline for group 2 but a significant increase in surface hardness for group 1 specimens (Fig 3). In fact, when Asepto-Sol served as the gauging liquid for Microstone (group 1), the mean KHN value rose to a level comparable to the type IV die stones. Die-Keen and Prima-Rock specimens were least affected by Asepto-Sol, and the KHN values for the two test groups were not significantly different from their controls.

Transverse Strength

The mean transverse strength of the stone specimens made from the PVS impressions was not statistically significant, except for the pairing of Die-Keen and Reprosil (Fig 4). The changes for all the other dental stones were small and not statistically significant. Specimens made from irreversible hydrocolloid impressions had mean transverse strength values that were not statistically different from one another for all seven dental stones ($P > .05$).

Discussion

The dental profession continues to search for improved methods to protect personnel and patients from possible microbial cross-contamination. To date, no single approach exists to accomplish this objective. It is recognized that microorganisms can be transferred to a gypsum cast from a contaminated dental impression.[2] Efforts to minimize the amount of microbial contamination vary widely. With one method, a chemical disinfectant is added to the powder of an irreversible hydrocolloid impression material, resulting in an antimicrobial irreversible hydrocolloid (Jeltrate Plus Antimicrobial Dustless Alginate, Dentsply/Caulk).[24] In another approach, a dry chemical disinfectant is incorporated into the gypsum powders.[22,23] Yet the most widely used disinfection protocols involve either spray

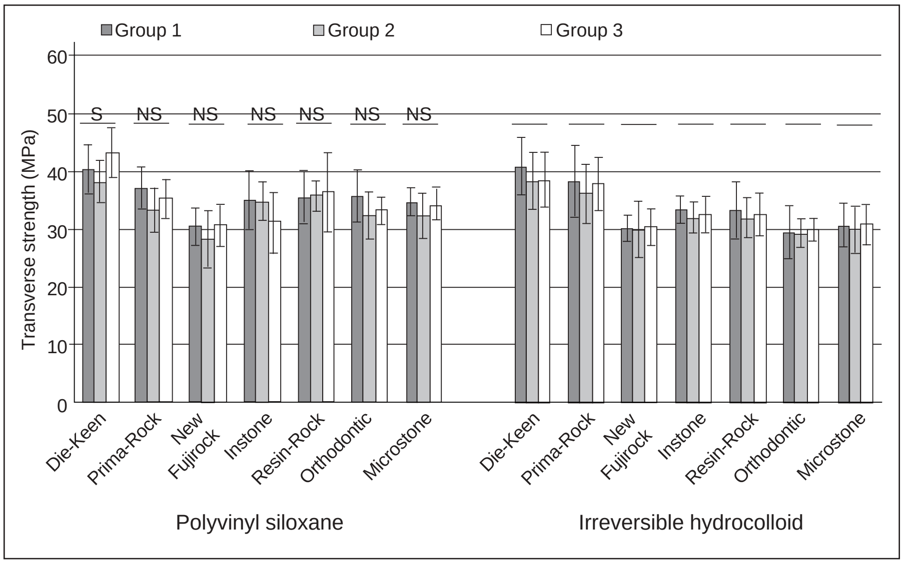

Fig 4 Effects of the two treatments on the transverse strength of the seven dental stones. *NS* = not significant ($P > .05$); *S* = significant ($P < .001$).

or immersion disinfection of dental impressions and casts using different chemical disinfectants.[1–14]

Casts made from Jeltrate Plus impressions underwent more linear dimensional change than those generated from Reprosil. However, the Orthodontic Stone group 1 and 2 specimens made from Reprosil were the only groups statistically different from their controls. No explanation was found for why New Fujirock–Reprosil casts shrank, although the amount of shrinkage was not significantly different from the New Fujirock controls. It was also apparent that New Fujirock and Jeltrate Plus were not compatible materials, and no specimens could be produced for this test. None of the remaining six dental stones underwent expansion or contraction that resulted in statistically significant linear dimensional change.

Subtle differences in detail reproduction were noted among the different dental stones and impression materials. Yet all the products met or exceeded the standard for detail reproduction specified in ANSI/ADA specifications No. 19 (the 20-μm-wide line) and No. 18 (the 50-μm-wide line). Gypsum specimens reproduced the 7- and 11-μm-wide lines with Reprosil impressions and the 19- and 28-μm-wide lines with Jeltrate Plus impressions, with the exception of New Fujirock and Jeltrate Plus. Die-Keen and Prima-Rock captured detail as fine as the 7-μm-wide line in their control specimens when poured against Reprosil, and lost little detail reproduction when exposed to Asepto-Sol. In four groups, the finest detail reproduction was seen with the control specimens (Die-Keen, Prima-Rock, Resin Rock, and Microstone) and the PVS impression material. In contrast, New Fujirock and Instone were not affected by Asepto-Sol and reproduced the 11-μm-wide line for all three groups. As stated previously, the exact nature of the New Fujirock–Jeltrate Plus incompatibility was not pursued but noted for the linear dimensional change and the detail reproduction tests. Acceptable specimens were produced for the Knoop hardness and transverse strength tests.

No single outcome described Asepto-Sol's effect on the surface hardness of gypsums. Changes were noted, but they were not consistent for all dental stones or methods of exposure. Knoop hardness tended to decrease for type III stones, increase for type IV stones, and remain unchanged for type V gypsum products. The surface hardness of dies and casts made from Reprosil and Jeltrate Plus impressions, however, may not be adversely affected by Asepto-Sol. The changes in hardness differed depending on which impression material was used for many of the gypsum–impression material pairings. The effects Asepto-Sol has on the Knoop hardness of a gypsum cast may not only be influenced by the method of delivery (groups 1 or 2), but by the type and brand of impression material used. Overall, any potential antimicrobial benefit derived from Asepto-Sol may outweigh minor changes in surface hardness.

Only Die-Keen casts derived from Reprosil impressions had a significant decrease in transverse strength, and only when sprayed with Asepto-Sol solution (group 2). This one negative outcome may be unique to the Die-Keen and Reprosil pairing because the transverse strength of Die-Keen and Jeltrate Plus specimens actually increased. Remarkably, in all the other pairings, none of the changes in transverse strength were statistically significant, suggesting that Asepto-Sol could be used with any of the products tested.

Adding resin to the gypsum powder may have other benefits, but improved surface hardness and transverse strength were not among them in this investigation. Specimens produced from the resin-gypsum type IV die stones did not have the highest transverse strength values.

Despite the introduction of disinfecting irreversible hydrocolloid impression materials and dental stones, clinicians and dental laboratory personnel may be reluctant to switch to new products or alter their techniques. The question that remains is whether a chemical disinfectant can be added to existing gypsum products without adversely affecting their physical properties. Our findings indicated that Asepto-Sol did not appreciably alter the physical properties tested to preclude its use with the dental stones tested. This outcome was consistent with other published reports.[7,21,26]

Conclusions

Based on the results of this study, two conclusions can be made:

1. Overall, type III, IV, and V dental stones did not appear to be affected by the Asepto-Sol solution. There were no adverse effects in linear dimensional change, detail reproduction, Knoop hardness, or transverse strength of the dental stones tested with either of the two impression materials. The chemical disinfectant may be mixed with gypsum powder or sprayed on dental impressions without adversely affecting the physical properties of the resulting gypsum casts.
2. The changes in physical properties associated with Asepto-Sol were not always the same between the PVS and irreversible hydrocolloid impression materials for each dental stone. Thus, the brand and type of impression material used may also influence the direction and extent of any changes, if changes do occur.

References

1. Firtell DN, Moore DJ, Pelleu GB. Sterilization of impression materials for use in the surgical operating room. J Prosthet Dent 1972;27:419–422.
2. Leung RL, Schonfeld SE. Gypsum casts as a potential source of microbial cross-contamination. J Prosthet Dent 1983;49:210–211.
3. Rowe AH, Forest JO. Dental impressions: The probability of contamination and a method of disinfection. Br Dent J 1978;145:184–186.
4. American Dental Association Council on Dental Materials, Instruments and Equipment. Infection control recommendations for the dental office and dental laboratory. J Am Dent Assoc 1988;116:241–248.
5. Centers for Disease Control. Recommended infection-control practices for dentistry. MMWR 1986;35:237–242.
6. Vandewalle KS, Charlton DG, Schwartz RS, Reagan SE, Kooppen RG. Immersion disinfection of irreversible hydrocolloid impressions with sodium hypochlorite. Part II: Effect on gypsum. Int J Prosthodont 1994;7:315–322.
7. Tan HK, Wolfaardt JF, Hooper PM, Busby B. Effects of disinfecting irreversible hydrocolloid impressions on the resultant gypsum casts: Part 2—Dimensional changes. J Prosthet Dent 1993;69:532–537.
8. Merchant VA, Radcliff RM, Herrera SP, Stroster TG. Dimensional stability of reversible hydrocolloid impressions immersed in selected disinfectant solutions. J Am Dent Assoc 1989;119:533–535.
9. Herrera SP, Merchant VA. Dimensional stability of dental impressions after immersion disinfection. J Am Dent Assoc 1986;113:419–422.
10. Adabo GL, Zanarotti E, Fonseca RG, Cruz CA. Effect of disinfectant agents on dimensional stability of elastomeric impression materials. J Prosthet Dent 1999;81:621–624.
11. Hutchings ML, Vandewalle KS, Schwartz RS, Charlton DG. Immersion disinfection of irreversible hydrocolloid impressions in pH-adjusted sodium hypochlorite. Part 2: Effect on gypsum casts. Int J Prosthodont 1996;9:223–229.
12. Rueggeberg FA, Beall FE, Kelly MT, Schuster GS. Sodium hypochlorite disinfection of irreversible hydrocolloid impression material. J Prosthet Dent 1992;67:628–631.
13. DeWald JP, Nakajima H, Schneiderman E, Okabe T. Wettability of impression materials treated with disinfectants. Am J Dent 1992;5:103–108.
14. Johnson GH, Drennon DG, Powell GL. Accuracy of elastomeric impressions disinfected by immersion. J Am Dent Assoc 1988;116:525–530.
15. Ivanovski S, Savage NW, Brockhurst PJ, Bird PS. Disinfection of dental stone casts: Antimicrobial effects and physical property alterations. Dent Mater 1995;11:19–23.
16. Breault LG, Paul JR, Hondrum SO, Christensen LC. Die stone disinfection: Incorporation of sodium hypochlorite. J Prosthodont 1998;7:13–16.
17. Ramer MS, Gerhardt DE, McNally K. Accuracy of irreversible hydrocolloid impression material mixed with disinfectant solutions. Int J Prosthodont 1993;6:156–158.
18. Touyz LZ, Rosen M. Disinfection of alginate impression material using disinfectants as mixing and soak solutions. J Dent 1991;19:255–257.
19. Soares CR, Ueti M. Influence of different methods of chemical disinfection on the physical properties of type IV and V gypsum dies. Pesqui Odontol Bras 2001;15:334–340.
20. Bass RA, Plummer KD, Anderson EF. The effect of a surface disinfectant on a dental cast. J Prosthet Dent 1992;67:723–725.
21. Sarma AC, Neiman R. A study on the effect of disinfectant chemicals on physical properties of die stone. Quintessence Int 1990;21:53–59.
22. Schutt RW. Bactericidal effect of a disinfectant dental stone on irreversible hydrocolloid impression and stone casts. J Prosthet Dent 1989;62:605–607.
23. Donovan T, Chee WWL. Preliminary investigation of a disinfected gypsum die stone. Int J Prosthodont 1989;2:245–248.
24. Lotzmann U, Patyk A, Hillebrecht S. Bacterial effects of antiseptic gypsum. ZWR 1989;98:964–968.