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Effect of Sodium Hypochlorite and Glutaraldehyde on Hardness of Calcium Sulphate Hemihydrate

Maahrukh Abbas[1], Irfan Ahmed Shaikh[1], Abdul Bari Memon[2*], Permanand[3], Muhammad Ahmed[4], Usman Bashir Shaikh[5] and Ghazanfar Ali Bhellar[6]

[1]Department of Prosthodontics, Liaquat University of Medical and Health Sciences, Jamshoro, Pakistan
[2]Department of Community Dentistry, Shaheed Mohtarma Benazir Bhutto Medical University, Larkana, Pakistan
[3]Department of Operative Dentistry, Bhittai Dental and Medical College, Mirpurkhas, Pakistan
[4]Department of Operative Dentistry, Liaquat College of Medicine and Dentistry, Karachi, Pakistan
[5]Department of Prosthodontics, Ziauddin University, Karachi, Pakistan
[6]Department of Oral and Maxillofacial Surgery, Bibi Aseefa Dental College, Larkana, Pakistan

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***Corresponding Author:**
Abdul Bari Memon
Department of Community Dentistry, Shaheed Mohtarma Benazir Bhutto Medical University, Larkana Pakistan
drabmemon@yahoo.com

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ABSTRACT

Calcium sulphate hemihydrate (CSH) is extensively used in dentistry for impressions, models, and casts due to its versatility. However, exposure to disinfectants like sodium hypochlorite and glutaraldehyde, commonly used in dental practices, can potentially alter CSH's mechanical properties. **Objective:** To measure the hardness of calcium sulphate hemihydrate cast after repeated immersion in sodium hypochlorite and glutaraldehyde solutions. **Methods:** This cross-sectional study was conducted at the Department of Prosthodontics, Institute of Dentistry LUMHS, Jamshoro and the Department of Mechanical Engineering, Institute of Mehran University of Engineering and Technology, Jamshoro. Test groups were divided into three groups i.e. Control group, Sodium hypochlorite (0.525%) and Glutaraldehyde (2%). Descriptive statistics were calculated. **Results:** Mean hardness in Group A was 8.94 ± 0.40, 8.40 ± 0.47 in Group B and 8.02 ± 0.59 in Group C. The mean hardness at the load of 10 kg in Group A, Group B and Group C was 7.01 ± 0.05, 7.31 ± 0.25, and 7.06 ± 0.04 respectively. Mean hardness at a secondary load of 60 kg in Group A, Group B and Group C was 6.95 ± 1.21, 7.48 ± 0.24 and 7.24 ± 0.05 respectively. The results showed a significant mean difference for mean hardness ($p = 0.000$), hardness at the load of 10 kg ($p = 0.000$) and hardness at the secondary load of 60 kg ($p = 0.036$). **Conclusions:** It was concluded that mean hardness was more in sodium hypochlorite group than control group and glutaraldehyde group.

INTRODUCTION

Numerous microorganisms found in saliva and blood are present in the oral environment. Some bacteria, fungi, and viruses, such as the HIV and Hepatitis-C viruses, may be fatal and incurable [1]. The bacteria may be spreading and becoming more common in the oral environment. Due to the poor state of infection control in our nation, both dental offices and dental laboratories must maintain and care for adequate infection control systems [2]. Evidence suggests that microorganisms can spread to the cast's surface from contaminated impressions, record bases, occlusion rims, and trial dentures [3]. Moslehifard E *et al.*, [4]. claim that between the time of manufacture and the distribution of a complete or removable partial denture, it may be essential to use disinfectants to clean the final cast at least seven times. The American Dental Association (ADA), the Centers for Disease Control (CDC), and other organizations have

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recommended a technique for disinfecting definitive casts that involves immersion in or spraying with a disinfectant [5]. Other methods, including adding chemicals to the gypsum while it is being mixed or using a die stone that contains a disinfectant, are said to have an impact on mechanical attributes like setting time and compressive strength along with dimensional accuracy [6]. It is crucial that the disinfectant not change the gypsum cast's physical characteristics, such as hardness [7]. When the wear process is believed to involve scratching, as in abrasive wear, hardness is used to indicate how resistant a material is to abrasion. Vickers, Knoop, Brinell, and Rockwell machines are frequently used techniques for evaluating hardness [8]. In their study of sodium hypochlorite's antimicrobial capabilities, Mansfield and White found that it reduces bacterial flow in experimental castings to zero in an hour [3]. It is widely utilized due to its accessibility and low cost [9, 10]. To ensure its effectiveness, the solution has to be produced fresh every day due to its weak stability [6-8]. According to a study, 2% glutaraldehyde is a highly effective disinfection with the fewest side effects on the cast's physical characteristics [10, 11]. Disinfection of the cast is essential to prevent cross-infection after every clinical visit but repeated disinfections might affect the physical properties of the dental cast, which in turn affects the retention, stability and dimensions of the final prosthesis [12]. This study aimed to compare the effects of two different disinfectants on the hardness of calcium sulphate hemihydrate (sodium hypochlorite and glutaraldehyde versus the control group). This study is beneficial for clinicians as well as technicians to maintain the physical strength and resistance to wear and abrasion of calcium sulphate hemihydrate for the fabrication of dental prostheses and the patients will have more stable prostheses.

METHODS

This study was conducted from April 2021 to November 2021 at the Department of Prosthodontics, Institute of Dentistry LUMHS, Jamshoro and the Department of Mechanical Engineering, Institute of MUET, Jamshoro (LUMHS/REC/-394). The sample size was calculated using an Epi tools analysis calculator. By taking the Mean 1 and variance 1 as 8.93 ± 0.73 (mean value of hardness of control group) [13] and Mean 2 and variance 2 as 8.35 ± 0.83 (mean value of hardness of sodium hypochlorite) [13] at a Confidence level of 95%, Power 80%, Ratio = 1:1, the sample size calculated was 74. It was divided into three groups. i.e. control group = 25, sodium hypochlorite = 25 and glutaraldehyde group = 25, so, the final sample size was 75. Inclusion criteria were specimen made from type-III dental stone, Specimen with immersion of test solution 1: Sodium hypochlorite and Specimen with immersion of test solution 2: Glutaraldehyde. Exclusion criteria were Specimens made of type I, and II dental plaster and Disinfectants such as Idophor, Formaldehyde, and Phenol. The data were collected from the Department of Prosthodontics, Institute of Dentistry, LUMHS, Jamshoro and the Department of Mechanical Engineering; Institute of MUET, Jamshoro. Gypsum specimens were prepared using Elite Model type III fabrications from Zhermack, Italy. By Adenosine Deaminase (ADA) Specification No. 25, hardness test samples with dimensions of 12 cm in height and 75 mm in diameter were manufactured and connected to a metal substrate. The silicone impression material was used to create the imprint materials. Dental stone was mixed with the recommended amount of powder and water in a rubber bowl, further blended by hand to achieve a smooth consistency, and then poured into the silicone mould using a mechanical vibrator (Vibromaster, BEGO, Bremen, Germany). A glass slab was then placed on top of the silicone mould to smooth out any uneven ends. The specimens (75 total, 25 per group) were permitted to set for an hour at room temperature. The cylindrical specimens were removed from the moulds after a setting period. Three groups of type III dental stones that had been prepared both before and after being disinfected with 0.525% sodium hypochlorite and 2% glutaraldehyde were used in the test group. In each group, there were 25 specimens. For their impact on the hardness of the cylindrical test specimen, three different solutions were used to prepare the disinfectant solution. Group acting as a control (using Slurry, a calcium sulphate supernatant solution in distilled water). Sodium hypochlorite (0.525%) is the first test solution. Glutaraldehyde (2%) is the second test solution. Immersion took place at room temperature for 30 minutes. The cylindrical specimens were taken out of their respective baths after immersion and left to dry for 24 hours at room temperature. Seven cycles of immersion & drying at room temperature were carried out, with the immersion bath solutions being changed after each cycle. The average number of immersions in a disinfecting solution required for the manufacture of fully and partially detachable prostheses was determined to be seven cycles. The Rockwell hardness testing device was created to gauge a substance's hardness. It has a two-stage application stainless-steel ball indenter. Stage one requires a weight loss of ten kilograms and stage two a weight loss of sixty kilograms. After being repeatedly submerged in disinfectants, the gypsum specimens of type III dental stone were placed on the Rockwell platform with the head of the instrument reduced until the indenter met the specimen's surface. At that point, a minor load was applied. The dial gauge had a reading of zero. A hardness reading was obtained after the secondary load had been applied for a minute. Thus, three sets of specimens received an aggregate of 75 readings. The SPSS version 21 program was used to enter and evaluate the data. The mean

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hardness and standard deviation (SD) of the data collected after contrasting the measurements of the specimens to the control group were calculated using descriptive statistics. For the three study groups (control group, glutaraldehyde, and sodium hypochlorite), frequency and percentage were compared. The mean hardness of the three groups was compared using a one-way ANOVA test. P values under 0.05 were regarded as significant.

RESULTS

This research aims to compare the hardness of calcium sulphate hemihydrate casts immersed repeatedly in glutaraldehyde and sodium hypochlorite solutions. The initial level of hardness in the control group was 8.64 + 0.63, the hardness of the Sodium hypochlorite (0.525%) group was 8.24 + 0.96 and the hardness of the Glutaraldehyde (2%) group was 7.96 + 0.93. The control group's findings were statistically insignificant (p = > 0.05), despite the high level of difficulty (Table 1).

Table 1: Hardness Level 1 Comparison in All Groups n=40

Study Groups	Hardness at Level 1		Mean Difference	p-value
A vs B	8.64 ± 0.63	8.24 ± 0.96	0.400	0.234
A vs C	8.64 ± 0.63	7.96 ± 0.93	0.680	0.018
B vs C	8.24 ± 0.96	7.96 ± 0.93	0.280	0.486

Group A = Control group (with Slurry, a supernatant solution of Calcium Sulphate in distilled water)
Group B = Test solution I: NaCl (0.525%)
Group C = Test solution II: Glutaraldehyde (2%)

The average hardness level at 10 kg in the control group was 7.02 + 0.51, the hardness of the Sodium hypochlorite (0.525%) group was 7.32 + 0.25 and the hardness of the Glutaraldehyde (2%) group was 7.06 + 0.48. The hardness level was high in the Sodium hypochlorite (0.525%) group, while the results were statistically insignificant (p = >0.05) (Table 2).

Table 2: Hardness Level 10 kg Comparison in All Groups n=40

Study Groups	Hardness at 10 kg		Mean Difference	p-value
A vs B	7.02 ± 0.51	7.32 ± 0.25	-0.298	0.234
A vs C	7.02 ± 0.51	7.06 ± 0.48	0.680	0.042
B vs C	7.32 ± 0.251	7.06 ± 0.48	0.280	0.257

Group A = Control group (with Slurry, a supernatant solution of Calcium Sulphate in distilled water)
Group B = Test solution I: Sodium hypochlorite (0.525%)
Group C = Test solution II: Glutaraldehyde (2%)

The average hardness level at 60 kg in the control group was 6.95 ± 1.212, the hardness of the Sodium hypochlorite (0.525%) group was 7.48 ± 0.249 and the hardness of the Glutaraldehyde (2%) group was 7.25 ± 0.053. The sodium hypochlorite (0.525%) group had a high hardness level, but the results were not statistically significant (p > 0.05) (Table 3).

Table 3: Hardness Level at 60 Comparisons in All Groups n=40

Study Groups	Hardness at 60 kg		Mean Difference	p-value
A vs B	6.95 ± 1.212	7.48 ± 0.24	0. 640	0.534
A vs C	6.95 ± 1.212	97.25 ± 0.05	0.880	0.296
B vs C	7.48 ± 0.249	37.25 ± 0.053	0.240	0.238

Group A = Control group (with Slurry, a supernatant solution of Calcium Sulphate in distilled water)
Group B = Test solution I: Sodium hypochlorite (0.525%)
Group C = Test solution II: Glutaraldehyde (2%)

DISCUSSION

There are varieties of microorganisms, fungi, and viruses that can be found in the atmosphere of a dentist practice and many of them have been connected to debilitating and life-threatening diseases [14-16]. The practice of general dentistry requires constant and direct physical interaction between the dental clinic and the dental laboratory [17]. It is possible to prevent a significant amount of the cross contamination that occurs when infectious materials are moved from the dental clinic to the dental laboratory [18]. As a result, every effort must be taken to prevent the possible spread of illness in the dental office and to stop these germs from mixing with one another. In this study, the average hardness level was high 7.32 + 0.25 in the Sodium hypochlorite (0.525%) group compared to the Glutaraldehyde (2%) group 7.06 + 0.48 and control group 7.02 + 0.51, while results were statistically insignificant. In a comparison of this study, Sanad ME *et al.*, [19] reported that the mean Hardness of group a Slurry (Group A) sample was 21.5, 0.525% sodium hypochlorite (Group B) was 15 and that of 1% Peroxygenic acid (Group C) was 21.4. Both the groups such as Slurry (Group A) and 1% Peroxygenic acid (Group C) showed same hardness. Sodium hypochlorite (Group B) showed lesser values as compared to Slurry (Group A) and Peroxygenic acid (Group C). Gypsum samples submerged in disinfectant solutions showed a decrease in hardness, which may have been caused by a chemical reaction between the disinfectant and stone. Gypsum may have reacted with this intense residual disinfectant to create decreased hardness. The mechanical strength differences between gypsum cleaned in all sorts of solutions are not of statistical significance, they added, based on the reasoning presented. On the other hand, 0.525% hypochlorite & Virkon [1% Peroxygenic acid] were examined by Moslehifard E *et al.*, [4] for their impact on the hardness of dental gypsum casts. They discovered that the reduction in hardness, which is least in the dental stones cleaned with Virkon [1% Peroxygenic acid], is caused by the development of micropores. Gypsum's compressive strength increases and the setting time lowers when 5.25% sodium hypochlorite solution is added, according to Craig RG [20] but all other physical characteristics stay the same. Because the studies mention utilizing several chemical disinfectants for spray & immersion disinfection for each

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impression and cast, immersion disinfection was employed. The full sets of parallel lines on the cast were studied using a stereo zoom microscope at a low magnification of 10, in low-angle lighting. Hardness can be measured using a micro-indenter with the Rockwell hardness scale. In one investigation, mean dimensional changes in gypsum specimens disinfected using sodium hypochlorite & glutaraldehyde were greater than those in slurry [21-24]. Gypsum products submerged in sodium hypochlorite and glutaraldehyde did not exhibit any discernible differences in dimensional change; instead, the solution's interaction with the toothstone caused the change [25-28]. In this study average hardness level at 60 kg in the control group was 6.95 ± 1.212, the hardness of the Sodium hypochlorite (0.525%) group was 7.48 ± 0.249 and the hardness of the Glutaraldehyde (2%) group was 7.25 ± 0.053. The hardness level was high in the Sodium hypochlorite (0.525%) group, while the results were statistically insignificant (p = >0.05). In a comparison of these results, Kumar RN *et al.*, [13] found that sodium hypochlorite had a worse impact on the tested properties than glutaraldehyde and chlorhexidine solutions. The hardness was measured using the Rockwell hardness test (R scale) with smaller loads of 10 kg and 60 kg. The hardness of the surface of type IV dental stone could be improved by coating its surface using cyanoacrylate resin, according to a study by Derrien G [29] that looked at the impact of cyanoacrylate on that stone's surface hardness. The current study had several limitations as a consequence, the results of the present investigation would have been impacted. In addition, these findings cannot be extended with perfect certainty to other brands of similar materials because there is a chance that even minute differences in chemical composition could result in dramatically different reactions. Skills on the part of the doctor are also necessary for the correct further manipulation of specimens.

CONCLUSIONS

It was concluded that as per the study conclusion it has been revealed the mean hardness at load of 10 kg and 60 kg was slightly more in the sodium hypochlorite group than in the control group and glutaraldehyde group. This study gives insight for clinicians as well as technicians to maintain the physical strength and resistance to wear and abrasion of calcium sulphate hemihydrate for the fabrication of dental prostheses and the patients will have more stable prostheses.

Authors Contribution

Conceptualization: IAF
Methodology: MA
Formal analysis: ABM
Writing-review and editing: MA, ABM, MA, UBS, GAB

All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest

The authors declare no conflict of interest.

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