



Comparative Evaluation of Tensile Strength in Die Stone Incorporated with Sodium and Calcium Hypochlorite as Disinfectants: An *in vitro* Study

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ABSTRACT

Aim: The aim of this study was to evaluate the tensile strength of die stone incorporated with sodium and calcium hypochlorite as disinfectants.

Materials and methods: Two commercially available type IV die stone (Kalrock: Kalabhai Karson Pvt., Ltd and Pearlstone: Asian Chemicals) and two commercially available disinfectant solutions (sodium hypochlorite and calcium hypochlorite: Beachem Laboratory Chemical Private Limited, Chennai and Leo Chem Private Limited, Bengaluru) were used in this study, and the tensile strength was measured using Lloyd's Universal Testing Machine.

Results: The results show that incorporating the disinfecting solutions decreases the tensile strength of both products. The effect of decreasing tensile strength on type IV gypsum product is seen more in calcium hypochlorite when compared with sodium hypochlorite disinfecting solution, and the tensile strength of Kalrock specimens is higher than Pearlstone specimens after disinfecting with sodium hypochlorite and calcium hypochlorite solution. The statistical results also show significant results in all the groups when compared with the control group.

Conclusion: The incorporation of sodium and calcium hypochlorite disinfecting solutions is not an encouraging method for both die materials as it reduces the tensile strength of type IV gypsum product. Tensile strength of Kalstone[®] die material is superior than Pearlstone[®] die material after mixing with sodium hypochlorite and calcium hypochlorite.

Clinical significance: According to the recommendations of Americans with Disability Act (ADA) and the Centers for Disease

Control and Prevention, disinfecting the whole cast without or minimal changes in physical and mechanical properties was the motto of the study. The tensile strength in type IV gypsum product plays a most important role in retrieval of cast from impression, especially in narrow tooth preparation. This study reveals that incorporating method of disinfecting solutions is not recommended as it reduces the tensile strength.

Keywords: Disinfectant solution, Gypsum product, Kalstone, Lloyd's universal testing machine, Pearlstone, Tensile strength.

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INTRODUCTION

Gypsum and its product are used since centuries in various fields. In dentistry, it was mainly used to make cast and as an adjunct to various dental laboratory operations that are involved in the fabrication of various oral and maxillofacial prostheses.^{1,2}

In fixed prosthodontics, precision is very vital and commonly used is type IV gypsum product for indirect method of fabrication of inlays, crowns, and bridges, which demands higher quality with respect to accuracy and strength.³ Therefore, type IV gypsum materials enjoy the popularity because of the ease of their manipulation and cost.

These stone models are obtained from the impressions which are susceptible for contamination and can generate a contaminated gypsum cast leading to cross-contamination between the dental personnel and the patient.⁴ Thus, it is always safe to follow the protocol of disinfection at every possible stage of fabrication of prosthesis to avoid cross-contamination.⁵

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The ADA and the Centers for Disease Control and Prevention have suggested methods for disinfection such as immersion or spraying with a disinfectant.^{5,6} The major disadvantage of these techniques is deterioration of surface quality and inability of surface disinfectant material to penetrate the cast, which might result in the core of the model being contaminated.^{7,8}

Hence, an alternative method should be opted wherein the whole bulk of the cast can be disinfected. One of the techniques involves incorporation of disinfectant into gauging water before addition of dental stone, which does not require extra laboratory time.⁹⁻¹²

Although the various studies have been conducted to evaluate the physical properties of cast gypsum after incorporation of disinfectants, spraying method, and immersion method, none have compared the tensile strength after incorporation of sodium hypochlorite and calcium hypochlorite solution as disinfecting solutions.^{13,14}

Nevertheless, type IV gypsum product is one among the popularly used gypsum product; it has a brittle quality too. Keeping in mind the safe disinfection protocol, it was decided to investigate and compare the tensile strength of common commercially available type IV gypsum die materials after incorporating sodium hypochlorite and calcium hypochlorite into distilled water.

AIM

The aim of this study was to evaluate the tensile strength in die stone incorporated with sodium and calcium hypochlorite as disinfectants.

MATERIALS AND METHODS

The study was done using two types of commercially available die stones (Kalrock: Kalabhai Karson Pvt., Ltd and Pearlstone: Asian chemicals) and two commercially available disinfectant solutions (sodium hypochlorite and calcium hypochlorite: Bechem Laboratory Chemical Private Limited, Chennai and Leo Chem Private Limited, Bengaluru), and the tensile strength was measured using Lloyd's Universal Testing Machine (Fig. 1).

Preparation of Gauging Water

Gauging water for NaOCl was prepared by adding 5.25% NaOCl into 100 mL distilled water in the ratio of 1:10 concentration according to ADA specification.

Gauging water for CaOCl₂ was prepared by adding 7.42 mL of CaOCl₂ solution (which contained 21 gm% of CaOCl₂) into 292.6 mL of distilled water and made it to 300 mL, to make 0.5% concentration using the chemical formula $C_1V_1 = C_2V_2$.



Fig. 1: Compressive load being applied

Fabrication of DIE

Dies were prepared using six cylindrical metal dies with dimensions of 20 mm in diameter and 40 mm height were fabricated as per ADA Specification No. 25 (Fig. 2). After that, an addition silicone duplicating material was mixed with ratio of 1:1 as per manufacturer's directions and was poured into the receptacle taking care that no air bubbles were trapped around the dies. After complete polymerization, metal cylinders were removed from the mold.

Specimen Preparation

A total of 90 specimens were made: 45 specimens of Kalrock and 45 specimens of Pearlstone and each product was further divided into three groups: groups I, II, and III with 15 specimens in each group (Fig. 3).

For fabrication of test specimens, both Kalrock and Pearlstone die stone powder were weighed on an electronic balance. The water:powder ratio was strictly followed according to manufacturer's instructions for all the groups. Distilled water was measured with the help

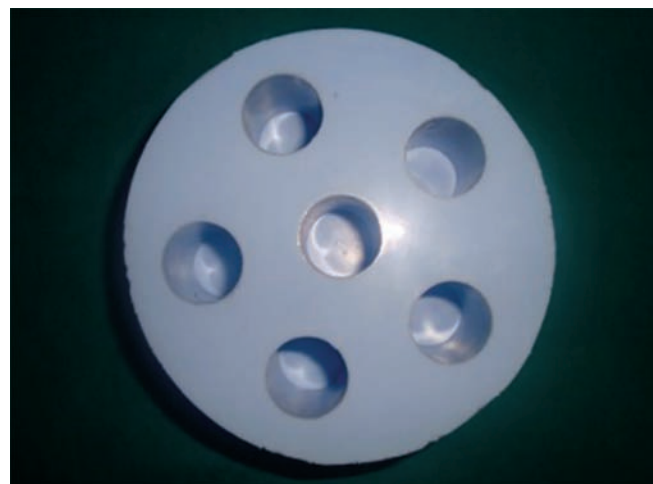


Fig. 2: Silicone mold



Fig. 3: Grouping of specimens

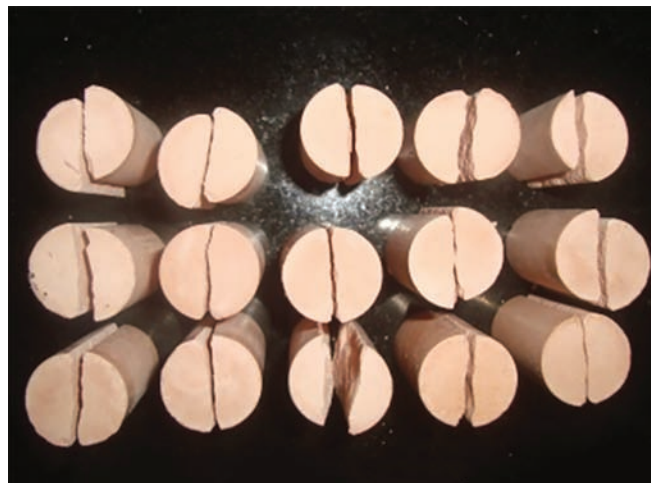


Fig. 4: Crushed pieces of a specimen

of a measuring cylinder with gradations of 0.5 mL and added into a rubber bowl.

The mix was carefully vibrated into the silicone mold. Glass slab was placed on top of the mold to obtain specimens with flat surface. They were allowed to set in the silicone mold for 40 minutes as per manufacturer's recommendation. Using compressed air, the specimens were carefully retrieved from the mold, air dried for 1 hour, and stored in airtight container.

The specimens of Product I (Kalrock[®]) and Product II (Pearlstone[®]) were subjected to compressive loading to evaluate diametral tensile strength of specimens using Lloyd's Universal Testing Machine.

Each specimen was placed between the metallic jigs fixed to the upper and lower counterparts of the universal testing machine. A gradually increasing compressive load was applied till specimen is crushed into fragments (Fig. 4) and digitalized readings were recorded in Newton/mm² (MPa). Values showing greater variations were discarded.

Later, the value was converted to kilo-Newton from megaPascal to calculate the tensile strength.

Tensile strength was calculated according to the formula:

$$\text{Tensile stress} = 2P/\pi \times d \times t \text{ (diameter thickness)}$$

The results obtained were tabulated and subjected to statistical analysis using two-way analysis of variance (ANOVA) test and t-test using Statistical Package for the Social Sciences (SPSS) software version 17.

DISCUSSION

The construction of working casts simulating intraoral relationship is essential in restorative dentistry. The surface mechanical properties of a die influence its ability to withstand forces associated with fabrication of a restoration. At the same time, infection control in dentistry

focuses on the prevention of cross-contamination among patients, dentists, and dental auxiliary personnel. Every impression presented to the laboratory might be contaminated and the die stone cast generated may cause cross-contamination between patients and dental laboratory personnel.

Hence, the present study was done to evaluate and compare the tensile strength between two products of type IV die stone by incorporating disinfectants into distilled water.

The strength of dental gypsum products has always been expressed as compressive or crushing strength and almost all reported work on the subject has involved compressive strength measurements. This is an important property when Plaster of Paris or dental stone is used as a mold material. However, in other cases, tensile strength is of more importance,¹⁵ e.g., when teeth fracture from a gypsum cast, they do so by failing in tension, especially during removal of stone casts with long and narrow tooth preparations, from elastomeric impressions.¹⁶

The oral environment harbors a large number of microorganisms in the saliva and blood that may contain infectious microbes. While the majority of these organisms pose no significant risk to dental professionals, a number of them cause infectious diseases that may be incurable, such as those caused by the hepatitis C and human immunodeficiency virus viruses.^{13,17}

Casts should be heat or gas sterilized before working with them or sending them to laboratory personnel. Sterilization is a process by which all forms of microorganisms, including viruses, fungi, bacteria, and spores, are destroyed.¹⁸

Sodium hypochlorite commonly known as bleach or liquid bleach and calcium hypochlorite is a chemical compound better known as bleaching powder which is considered relatively stable and has greater available chlorine for disinfection.⁶

If disinfectants are to be incorporated into gypsum product, it should not affect the physical properties, meanwhile demonstrating antimicrobial effect too, to serve the purpose.

Breault et al¹¹ had conducted a study in which gypsum casts may be effectively disinfected by the substitution of 10% gauging water with 5.25% solution of sodium hypochlorite and the results showed that there is increase in compressive strength and rigidity, decrease in setting time, and there is no change in tensile strength, hardness, and setting expansion or detail reproduction.⁷

Jonathan et al⁸ used calcium hypochlorite as a disinfectant additive to type V dental stone and evaluated for physical properties such as compressive strength and tensile strength and concluded that it decreased the number of viable microorganisms with adequate compressive and tensile strength.¹⁹

In agreement with the study done by Abdelaziz et al,²⁰ Jonathan et al, and Breault et al,¹¹ the assumption is that the sodium ions from the hypochlorite interfere with the structure and strength of gypsum which contain calcium in its structure. At the same time, in the present study, CaOCl₂ incorporated into die stone showed the weakest fracture strength, i.e., the least in tensile strength when compared with both, specimens with distilled water and specimens with sodium hypochlorite.

The present study is in agreement with the above-mentioned studies, where 5.25% NaOCl was incorporated into 100 mL distilled water, to obtain 0.525% NaOCl as gauging water as per ADA standards and 7.42 mL of CaOCl₂ solution (which contained 21 gm% of CaOCl₂) was added to 292.6 mL of distilled water and made it to 300 mL, to make 0.5% concentration of gauging water, using the chemical formula $C_1V_1 = C_2V_2$. The type IV gypsum products (die stone) were then measured in the electronic weighing machine and incorporated into gauging water separately.

The mix was incorporated into silicone mold, which was fabricated from metal die of dimensions 40 mm height and 20 mm diameter (Fig. 2), according to ADA Specification No. 25, duplicated using the silicon duplicating material. In this study, two popular type IV gypsum products (die stones) were used, which were easily available in the market and grouped as die material I and die material II.

The specimens in each type were grouped as I, II, III, and stored at room temperature and tested for tensile strength using Universal Testing Machine at a cross-head speed of 1 mm/minute. Values obtained were statistically analyzed. It was concluded that NaOCl incorporated type IV gypsum products specimens showed decrease in tensile strength when compared with the control group specimens, and increase in tensile strength when compared with the calcium hypochlorite incorporated

type IV gypsum products specimens in both group of die material I and II (Kalrock[®] and Pearlstone[®]). Moreover, on comparison of two commercially available die materials, Kalrock[®] and Pearlstone[®], Kalrock[®] had a superior tensile strength when compared with Pearlstone[®] (Fig. 3).

The overall statistical analysis was done using two-way ANOVA test and t-test by SPSS version 17, which signifies that the significant difference is seen in die material I and II and statistical significance among the test specimens of both die material I and II. It also shows there is significant difference in interaction of test specimens with the control ($p = 0.02$).

Results of this study show that incorporating the disinfecting solutions such as sodium hypochlorite and calcium hypochlorite decreases the tensile strength of both products. The effect of decreasing tensile strength on type IV gypsum product is seen more in calcium hypochlorite when compared with sodium hypochlorite disinfecting solution (Table 1), and the comparison between two products, i.e., Kalrock[®] and Pearlstone[®] die materials, clearly indicates that the tensile strength of Kalrock specimens is higher than Pearlstone specimens after disinfecting with sodium hypochlorite and calcium hypochlorite solution (Table 2). The statistical results also

Table 1: Comparison of mean tensile strength and standard deviation of die material I in both control and disinfected samples

Group	n	Mean ± SD	Minimum	Maximum
I*	15	9.349640 ± 0.6604254	7.9690	10.1760
II*	15	7.748867 ± 0.3880795	7.1840	8.6090
III*	15	7.254133 ± 0.3912650	6.5490	8.0410
I vs II	p < 0.0005			
I vs III	p < 0.0005			
II vs III	p = 0.025			

Group I* (control group) die stone was incorporated into distilled water; Group II* die stone was incorporated into gauging water with NaOCl; Group III* die stone was incorporated into gauging water with CaOCl₂; SD: Standard deviation

Table 2: Interproduct comparison of mean tensile strength and standard deviation between die material I and II within groups I, II, and III respectively

Group	Die material	n	Mean ± SD	p-value
I*	Kalrock I	15	9.349640 ± 0.6604254	<0.0005
	Pearlstone II	15	7.754867 ± 0.3518609	
II*	Kalrock I	15	7.74887 ± 0.388079	<0.0005
	Pearlstone II	15	6.72260 ± 0.622675	
III*	Kalrock I	15	7.25413 ± 0.391265	<0.0005
	Pearlstone II	15	6.36200 ± 0.519819	

Group I* (control group) die stone was incorporated into distilled water; Group II* die stone was incorporated into gauging water with NaOCl; Group III* die stone was incorporated into gauging water with CaOCl₂; SD: Standard deviation

show significant results in all the groups when compared with the control group (Fig. 4).

Within the limitation of the study, it can be concluded that incorporation of sodium and calcium hypochlorite disinfecting solutions is not an encouraging method for both die materials as it reduces the tensile strength of type IV gypsum product.

CONCLUSION

Within the limitations of the present study and based on the results obtained, it can be concluded that the incorporation method of disinfecting type IV gypsum product using sodium hypochlorite and calcium hypochlorite disinfecting solution shows decrease in fracture resistance. The effect of decreasing tensile strength on type IV gypsum product is seen more in calcium hypochlorite when compared with sodium hypochlorite disinfecting solution. The tensile strength of Kalstone[®] die material is superior than Pearlstone[®] die material after disinfecting with sodium hypochlorite and calcium hypochlorite disinfecting solutions. The incorporation of sodium and calcium hypochlorite disinfecting solutions is not an encouraging method for both die materials as it reduces the tensile strength of type IV gypsum product.

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