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Comparison of Tap Water, Distilled Water and Slurry Water on Surface Hardness of Gypsum Die

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The aim of this *in vitro* study was to evaluate the effect of three liquid types including tap water, distilled water and slurry water on surface hardness of type IV gypsum (GC Fuji Rock, Japan). For each studied groups, 10 dies were produced according to the manufacturer's instructions whereby gypsum powder were mixed with three different liquids. Twenty four hours after producing the dies, hardness measurement test was carried out by way of microvickers and using the set (MATSUZAVA, MHT2, Japan) and penetration time of 5 sec and power of 25 g. The test was carried out on three points of each die's surface and averages of hardness of dies were measured. The obtained data were evaluated by using of one-way ANOVA test as well as Tukey test using SPSS program. Results showed that the average of surface hardness between the three studied groups, have significant statistical differences with each other ($p<0.001$). In the range of this study, it was shown that distilled water and slurry water produced the most and the least surface hardness when they mixed with gypsum type IV respectively.

Key words: Surface hardness, gypsum, distilled water, slurry water

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INTRODUCTION

One of the most important laboratory procedures in fixed prosthesis is to produce gypsum die. Due to the economical, physical and mechanical properties of gypsum, it has wide applications in fixed prosthesis treatments (Powers and Sakaguchi, 2006). One of the characteristics of the gypsum die is its surface hardness. The higher the surface hardness of gypsum die, the lower the possibility of damaged while waxing up. There are different methods to increase hardness of gypsum die. One method is using the highest ratio of gypsum powder to water, which has limited application because of increasing viscosity of mixture. Another method is using hardener liquids instead of water, while mixing the gypsum with a liquid (Craig *et al*., 2004).

Sanda *et al*. (1982) recommended that adding calcium oxide and Arabic Gum to gypsum increases mechanical properties of gypsum die such as hardness. Abdelaziz *et al*. (2002) concluded that the surface roughness of stone casts was adversely affected by using the disinfectant solutions as mixing water substitutes. Rosentiel *et al*. (2006) found that gypsum hardener (e.g., colloidal silica) have relatively little effect on the hardness of the stone.

There has been this question whether materials and salts existing in tap water can be effective on hardness of stone gypsum type IV and whether simpler methods than what was described in preceding research studies such as using distilled water and liquid saturated of used gypsum particles can increase hardness of gypsum after setting. The purpose of this study was to evaluate effects of distilled water, slurry water and tap water on surface hardness of type IV gypsum.

MATERIALS AND METHODS

This study was conducted at the Center of Mashhad Dental Research of Mashhad University of Medical Sciences in 2006. In this experimental *in vitro* study, 30 gypsum dies were produced. Studied samples consisted of three ten-member die groups, using tap water in the first group, distilled water in the second group and slurry water in the third group mixing with one typical type IV gypsum (GC Fuji Rock, Japan). To produce gypsum dies, PVC tubes of 2 cm diameter and 1 cm height were used. In each group, 20 cc of liquids were mixed with 100 g of stone for 45 sec to fill tubes. Slab glasses were placed, until setting the gypsum, on the upper surface of the tubes to assure that surface of mixes are smooth and even. According to the recommendation of the manufacturer of gypsum GC, gypsum dies were kept at temperatures of 25°C and humidity of 35% for 24 h. A Vickers microhardness measurement method was used to measure hardness of all dies (MATSUZAVA, MHT2, Japan). Hardness measurement was conducted three times on each sample in three separate points under standard condition of penetration time of 5 sec and power of 25 g. Using a microscope equipped with a micrometer, diameters of Rhombus, resulting from the penetration of indentor to gypsum surfaces, were carefully measured. The average of three measurements on each sample was calculated. Data were analyzed by using statistical tests such as one-way ANOVA test and Tukey test using SPSS software.

RESULTS AND DISCUSSION

The results of this study showed that the average of surface hardness of dies produced from one typical gypsum and tap water was equal to 34.5 VHN (SD = 5.06). The average of hardness for dies made with distilled water was 41.9 VHN (SD = 5.74) and finally, the average hardness for dies made with slurry water was 30.4 VHN (SD = 3.78). Table 1 presents summary of hardness testing results for dies made with three liquids used in this study. The results of one-way ANOVA revealed that the hardness testing results of these three groups were significantly different ($F = 41.8$, $p<0.001$).

The results of Tukey test showed that this difference was between slurry water and tap water ($p = 0.005$), slurry water and distilled water ($p<0.001$), tap water and distilled water ($p<0.001$).

One important consideration in producing stone die is increasing its surface hardness because working with die with spatula (wax-up) can damage die's surface (Lindquist *et al*., 2003). Any damage in gypsum die while working with it causes discrepancies in fitness of wax pattern and consequently results inconsistencies on metal frame and finally destruction of abutment teeth. One of the substances, which can be effective on surface hardness of gypsum die, is the liquid which gypsum is mixed with it. In this study three liquids were used for mixing with gypsum (Tap water, Distilled water and Slurry water) and their surface hardness of dies were examined. Surface hardness is the resistance of any subject against the indent of an object harder than itself (Powers and Sakaguchi, 2006). Several researches have studies been carried out regarding the mixing elements with gypsum and their effects on surface hardness.

Reviewing the literature, it was found that different materials have been examined to increase the gypsum hardness. Duke *et al*. (2000) found that the resin-modified gypsum products were not significantly superior

Table 1: Means comparison of hardness of stone dies (VHN)

Liquid type	Sample No.	Mean (SD)	Min.	Max.
Tap water	10	34.5 (5.06)	25.1	47.3
Distilled water	10	41.9 (5.74)	30.2	52.5
Slurry water	10	30.4 (3.98)	25.8	37.8

to the conventional type IV gypsum die materials. Abdelaziz *et al*. (2002) found that Gum Arabic and calcium hydroxide additives can yield a hardener stone surface without compromising other surface properties. Habib *et al*. (1983) recommended using ciano acrylateon on gypsum for increasing hardness. However, Harris *et al*. (2004) stated that die hardener coating (cyanoacrylate and clear coat) reduces the surface hardness of the gypsum material. The study of Lindquist *et al*. (2003) demonstrated that a significant improvement in abrasion resistance occurred only with specific gypsum/surface hardener material combinations. Also, water sorption decreased significantly for microstone and silky-rock gypsum materials when a surface hardener was used. Gypsum manufacturers recommended none of the mentioned methods and there is no information about the effect of these materials on the other dimensional and physical properties of gypsum after setting.

In this study the least surface hardness was related to slurry water group (30.4 VHN) and the most surface hardness is related to distilled water group (41.9 VHN). As all variables were the same for all dies, the difference in surface hardness could be related to three used liquids. Tap water naturally has some salts such as calcium, magnesium, iron, copper, sulfate, cholera, ammoniac and nitrate. In tap water that passes through galvanized tubes, Fe and Zn were seen. Salts existing in water are found as combination such as calcium bicarbonate, sulfated calcium and sulfate magnesium. It must be mentioned that the amount of such salts existing in water is also related to geographical and other conditions. In low amounts, non-organic salts like calcium sulfate play as catalyst as the nucleus of crystallization whereby in these centers crystals of calcium sulfate dehydrate form and grow (Craig *et al*., 2004; Stewart *et al*., 1992; Phillips, 1991; Anusavice, 2003). These crystals decrease setting time and induction period of gypsum die (Phillips, 1991). In slurry water the amount of calcium sulfate has been more than needed. Calcium sulfate particles which are called tera alba in some books when are added to water in amount 0.05-0.01% (Craig *et al*., 2004).

In the two groups of gypsum made with tap water and slurry water, as the salts play as catalyst, crystals of dehydrate calcium sulfate which have spherulitic shape, form sooner and are thicker and shorter than normal dehydrate calcium sulfate and their induction time becomes shorter. However in the normal state after forming spherulitic crystals, they continue their growth and eventually form intermeshing crystals, which create a strong solid. This case did not occur while using water consisting of salts and as a result gypsum bulk has less surface hardness after setting (Phillips, 1991).

When some salts exist in water, the strength of gypsum and consequently its surface hardness decreases. Some salts (for instance calcium sulfate) act as adulterant and decrease adhesion among crystals. When the adhesion decreases, surface hardness also decreases (Phillips, 1991). The results of this research are important because dental technicians usually use tap water for mixing with gypsum powder. This matter can affect on the die hardness and the quality of final work.

CONCLUSION

In the range of this study, it has been shown that in procedure of preparing gypsum die, distilled water causes the maximum hardness and slurry water the minimum hardness. We recommend that using distilled water, while mixing the gypsum with a liquid in order to increase the surface hardness of gypsum die.

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