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Original research

A new dental casting technique for production of void-free dental models

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Purpose
An essential of successful dental prosthesis is dental models. Voids present in dental models decreases accuracy and strength. This study investigates void formation in models fabricated by a new technique. The technique described in the study was based upon increasing soaking time of gypsum powder in water.

Materials and Methods
Voids in hand mixed, hand mixed after a soaking time of 1.5 minutes and vacuum mixed samples were examined. The voids were counted via a stereomicroscope and diameters of voids were recorded in 2 categories (0.01-0.05mm, 0.051-0.1mm). The amounts of voids were compared between the samples prepared with 3 methods.

Results
The samples prepared by conventional hand mixing method had the highest total number of voids and smaller voids. There was no significant difference between the amount of voids in the samples prepared by soaking powder in water and by mixing under vacuum.

Conclusion
Soaking gypsum powder in water for 1.5 minutes before mixing may be an alternative to mixing gypsum under vacuum to avoid void formation in dental models.

Keywords: *Dental model, Dental prosthesis, Void, Microscopy, Dental casting technique*

Introduction

Gypsum products has been the most widely material to produce diagnostic cast, working cast and dies. Desirable qualities for instance hardness, strength, accuracy, detail reproduction, resistance to abrasion, minimal solubility, stability, ease of handling, cost and color depend on the utilization of the product. Gypsum powder used in dentistry consists of calcium sulfate hemihydrate and forms a viscous material after being mixed with water. After the chemical reaction occurs, calcium sulfate hemihydrate turns into calcium sulfate dehydrate. The amount of water required to mix with powder is greater than the amount required for the reaction. This excess water vaporizes during stiffening and a mass of interlocking gypsum crystals is formed. Voids occur between these crystals after evaporation of the water. Strength, resistance to abrasion and hardness are affected from the amount and size of the voids (1). In addition to product of the reaction, voids are formed by the incorporation of air during mixing process and pouring mixture into an impression material.

Mixing dental stone with a motorized vacuum mixer that simultaneously extracts air and spatulates the mixture at a constant rate, minimizes air incorporation (2, 3). The impression pouring technique consists of carrying and placing the gypsum slurry to the impression. Carrying the

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slurry can be performed by using a spatula or a syringe (4). A mechanical vibrator is suggested to enable the slurry to flow and spread into the impression. The rate of flow and spread depends on the frequency and amplitude adjustment of the vibrator (5,6). Excessive speed can incorporate air bubbles into the mixture. Gathering small increments of the slurry and placing at a posterior region of the impression, adding the increments till the anatomic indentations critical for the restoration are filled are the tips advised to avoid void formation (1). Type of impression material is another determinant of void formation. As the wettability of the impression material increases, the size and number of voids decrease (6-8).

In this study, a new technique of cast fabrication has been described. The purpose of this research was to compare number and size of voids in the models prepared by using this new technique with hand and vacuum mixed models.

Materials and Methods

A total of 18 dental stone specimens were prepared by pouring gypsum slurry into silicone model former molds by an experienced dental technician. Water/powder ratio was 0.26 and soaking time before mixing was 30 seconds as recommended by the manufacturer (Type III, Alston, Ata Alçı Sanayi ve Ticaret AŞ, Ankara, Turkey). The specimens were divided into 3 groups regarding mixing methods; hand mixed (H), powder soaked in water (S) and vacuum mixed (V). For group H, room temperature distilled water was placed in a rubber bowl and dental stone powder was added to water. After soaking time of 30 seconds, the slurry was mixed for 1.5 minutes with a steel blade spatula. For group S; room temperature distilled water and powder were placed in a bowl, waited for 1.5 minutes, and then spatulated for 30 seconds with a spatula. For group V, the slurry was mixed under vacuum for 1 minute by using vacuum mixing machine (EasyMix, BEGO Gmbh & Co KG, Bremen, Germany). All mixtures of dental stone was poured to the molds on a mechanical vibrator (Rotaks-Dent Dişçilik San. ve Tic. A.Ş. İstanbul, Turkey) for 25 seconds at a vibration frequency of 3000cycles/minute.

All casts were separated from the molds after a waiting time of 1 hour for setting. Thereafter, 2 mm thicknesses was cut from middle region of the casts by the use of a model trimmer (Rotaks Dent, İstanbul, Turkey). Four regions 7 mm to edge and 4 regions 10 mm to centre of the samples were marked on every 2 mm thick specimens and numbered (Figure 1). The marked regions of the specimens were examined with a stereomicroscope (Leica EZ4 HD, Leica Microsystems GmbH, Wetzlar, Gemany) under x35 magnification and x10 eyepieces for detection of air voids. Examples of the images captured with the microscope are shown in Figures 2-4. The voids having diameter 0.01-0.05 mm and 0.051-0.1 mm were counted and recorded. Localizations of voids were also recorded as edge or centric region to examine the relation between voids and localization.

Statistical analysis

The tendency of quantitative variables was determined using centralization and variance measures. Kruskal-Wallis H Test was used to compare the differences between the amounts of voids counted in 3 groups. The differences between the amounts of voids found in 2 different regions (center, edge) were compared using Mann-Whitney U Test. All hypotheses were tested at 0.05 significance level. All analyzes were performed using IBM SPSS (Statistical Package for Social Sciences for Windows, Version 21.0, Armonk, NY, IBM Corp.).

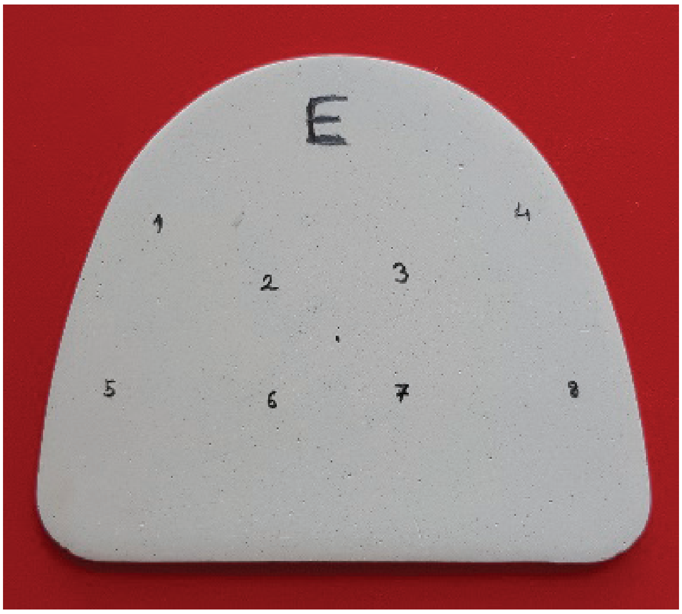

Figure 1. *Landmarking of a sample.*

Figure 2. *Microscopic image of a hand mixed sample.*

Figure 3. *Microscopic image of a soaked sample.*

Figure 4. *Microscopic image of a vacuum mixed sample.*

Results

A statistically significant difference was found between the groups in terms of total number of voids (p<0.001). The number of voids in group H was higher than that of group S and group V. There was no statistically significant difference between total voids of the group S and V (Table 1, Figure 5).

Table 1. *Kruskal Wallis table*

Group	H (48)	S (48)	V (48)	*p-value*
	Mean ± SD / Median (Min–Max)			
Total void	9.4±4.52	4.67±1.94	4.17±2.68	*<0.001*
	9 (2-21)	5 (1-11)	4 (0-11)	
Large void	0.44±0.8	0.52±0.71	0.35±0.84	*0.185*
	0 (0-3)	0 (0-2)	0 (0-4)	
Small void	8.96±4.24	4.15±1.73	3.81±2.29	*<0.001*
	9 (2-20)	4 (1-10)	4 (0-8)	

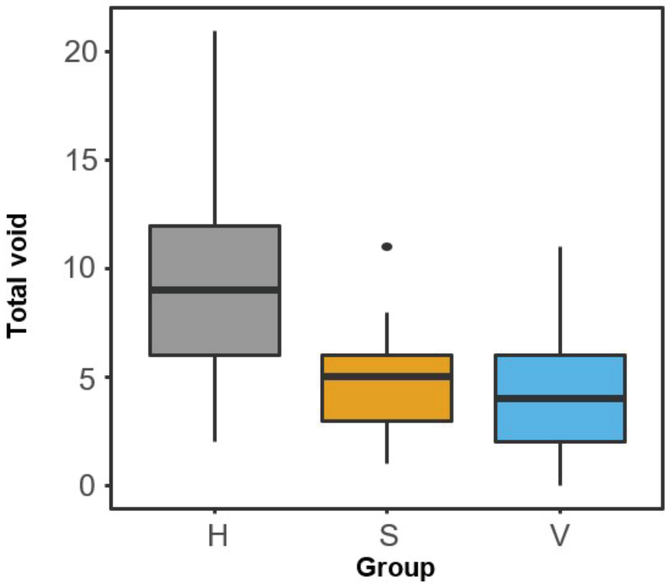

Figure 5. *Comparison of total voids.*

Difference between the amount of 0.051-0.1 mm voids were not significant (p=0.185). The groups showed significant difference with regard to smaller voids (0.01-0.05 mm, p<0.001). It was observed that the total number of small voids in group H was higher than that of group S and group V. There was no statistically significant difference between small voids of the group S and V (Table 1, Figure 6).

The number of total, large and small voids for 3 groups was compared by localization and no significant difference w found (Table 2).

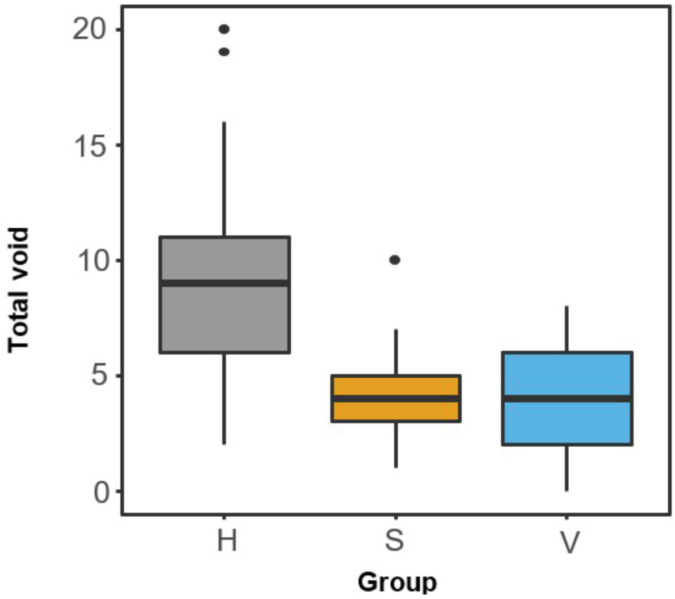

Figure 6. *Comparison of small voids.*

Table 2. *Mann Whitney U table*

Localization	Edge (72)	Center (72)	*p-value*
	Mean ± SD / Median (Min–Max)		
Total void	6.21±3.84	5.94±4.16	0.604
	5 (1-18)	5 (0-21)	
Large void	0.47±0.9	0.4±0.64	*0.794*
	0 (0-4)	0 (0-2)	
Small void	5.74±3.51	5.54±4.03	0.48
	5 (1-16)	5 (0-20)	

Discussion

Amount and size of voids effect mechanical properties of casts. One of the reasons of void formation is the gypsum mixing method (2). Soaking dental stone powder in water for 30 seconds before mixing is recommended for allowing particles to get wet (1). In this study wetting time was increased to 1.5 minutes. The amount and size of voids were compared with conventional hand mixing method and vacuum mixing method.

Mixing gypsum under vacuum is a known fact that it reduces air trapped in the mixture (9). Results of the study showed that dental stone samples fabricated with soaking method had same amount of voids with that of vacuum method and less voids than hand mixed group. Spatulation disrupts precipitation centers forming new nuclei. Nuclei act as centers of crystalline growth (3). In the study, hand mixed group had longer spatulation time. Longer spatulation probably caused more crystalline growth forming more voids. The other possibility is that less spatulation caused less air incorporation in the soaked group.

Considering large pores causes less accuracy and strength for casts than small ones, the study included 2 categories of void size. Although there were no significant difference between the groups by means of 0.051-0.1 mm voids, amount of 0.01-0.05 mm voids were found higher in Group H than other groups. Small pores may result in decreased strength as large pores do if the amount is high.

In the literature, recent researches about pores of dental models seems to be limited with wettability of impression materials (10), effect of pre-impression procedures (11), comparison of dental stone types (12). There only few studies about the effect of mixing method on void formation after the superiority of the vacuum mixer had been proved. Akpınar et al. described a new method to decrease voids of the casts (13). They compared the amount of voids between mixed with hand, vacuum mixer and a vacuum cabin designed for the research. The vacuum cabin described in the study decreased the void formation.

Computer-aided design/computer-aided manufacture (CAD-CAM) system enables the fabrication of a prosthesis without a working model. However, a model is still required to carry out the fit test and modify the prosthesis. In addition to this, diagnosis and manufacture of orthodontic devices and surgical guides require models (14,15). Altough working models can be produced with CAD-CAM, low financial capability of dental laboratories and state dental clinics especially in developing countries may not enable to have a CAD-CAM equipment. In these circumstances, the technique of model fabrication described in this study may be used instead of conventional hand mixing or as an alternative to mixing under vacuum.

The amount of voids in the models produced with this new method may be compared with the ones produced with CAD-CAM in another study. This study was limited only with the models made of Type III dental stone. Another research should be carried out using Type IV dental stone which is used mostly for fixed partial denture. A further study testing compressive strength and hardness of the casts produced with this new method would support the results of this research.

Conclusion

According to the results of the present study, soaking powder in water for 1.5 minutes before mixing dental stone may be an alternative method to the vacuum mixing method especially in low financial conditions.

Türkçe Özet: *Boşluksuz dental model yapımında yeni bir model elde etme tekniği. Amaç: Dental modeler başarılı dental protezlerin bir gerekliliğidir. Dental modellerde bulunan boşluklar hassasiyet ve dayanıklılığı azaltmaktadır. Bu çalışma yeni bir teknik ile üretilen modellerde boşluk oluşumunu araştırmıştır. Çalışmada tarif edilen teknik, alçı tozunun suda bekletilme süresinin arttırılmasını temel almaktadır. Gereç ve Yöntem: Elle karıştırılmış, 1.5 dakika beletme sonrası elle karıştırılmış ve vakum ile karıştırılmış örneklerdeki boşluklar incelenmiştir. Bir stereomikroskop yardımıyla boşluklar sayılmış ve boşluk çapları 2 kategori altında (0.01-0.05mm, 0.051-0.1mm) kaydedilmiştir. Üç yöntem ile hazırlanan örnekler arasında boşluk miktarları karşılaştırılmıştır. Bulgular: Geleneksel el ile karıştırma yöntemi kullanılarak hazırlanan örneklerin en fazla toplam boşluk ve küçük boşluğa sahip olduğu belirlenmiştir. Tozun suda bekletilmesi ve vakum altında karıştırma yöntemleri ile hazırlanan örneklerdeki boşluk miktarları arasında istatistiksel olarak anlamlı fark saptanmamıştır. Sonuç: Dental modellerde boşluk oluşumunu önlemek için; karıştırma öncesi alçı tozunun suda 1.5 dakika bekletilmesi, alçının vakum altında karıştırılmasına alternatif olabilir. Anahtar Kelimeler: Dental model, Dental protez, Boşluk, Mikroskop, Dental model elde etme tekniği*

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