ISSN: 2581-5989
PubMed - National Library of Medicine - ID: 101738774

International Journal of Dental Science and Innovative Research (IJDSIR)

IJDSIR : Dental Publication Service

Available Online at: www.ijdsir.com

Volume – 4, Issue – 2, April - 2021, Page No. : 88 - 96

Effect of Frequency and Amplitude of Vibration on Void Formation in Dies Poured from Polyvinylsiloxane Impression Material

[1]Dr. Nagaral Sharanbasappa, Professor and HOD, Department of Prosthodontics, Including Crown And Bridge, Albadar Rural Dental College And Hospital, Kalburagi-585102

[2]Dr. Rudrappa. S. G, MDS, Reader, Albadar Dental College, Gulbarga, Karnataka, India.

Corresponding Author: Dr. Nagaral Sharanbasappa, Professor and HOD, Department of Prosthodontics, Including Crown And Bridge, Albadar Rural Dental College And Hospital, Kalburagi-585102

Citation of this Article: Nagaral Sharanbasappa, Rudrappa SG, "Effect of Frequency and Amplitude of Vibration on Void Formation in Dies Poured from Polyvinylsiloxane Impression Material", IJDSIR- April - 2021, Vol. – 4, Issue - 2, P. No. 88 – 96.

Type of Publication: Original Research Article

Conflicts of Interest: Nil

Abstract

Aim: The aim of study was to determine the effect of frequency and amplitude of vibration on void formation in dies poured from poly vinyl siloxane impression using mechanical model vibration.

Materials and Methods: Impressions were poured in die stone using mechanical model vibrator which was set at frequency 3000cycles/min and 6000cycle/min and amplitude of vibration at 5 different steps. The amplitude was measured by using surface vibrator machine and oscilloscope. The vibrator was set at low frequency 3000cycle/min and ten dies are poured at each step of amplitude for 5 steps of amplitude and vibrator was set at high frequency 6000cycle/min and 10 dies are poured at each step of amplitude for 5 steps of amplitude. A total of 100dies were poured and the resultant dies are examined for presence of voids at margin and surface under 10X magnification.

Results: Means for voids in all dies group calculated for Low and High frequencies indicated that an increase in the magnitude of amplitude caused an increase in the number of voids on the die margin and surface.

Conclusions: The frequency and amplitude of vibration have a definite relationship in formation of voids in dies (type IV) poured from poly vinyl siloxane impression material impression poured at Low frequency 3000cycle/min vibration as maximum voids were found. Impressions poured at high frequency 6000cycles/min and amplitude of step of 3 (0.4mm) reduces number of voids on the margin and surface.

Keywords: Frequency, Amplitude, Vibration Impression material, Voids, Cast dental restorations.

Introduction

The fit and ultimate clinical success of cast dental restorations is dependent upon the accuracy and completeness of die reproduction[1]. Preparation of void free dies is important in the construction of accurate die restorations[2]. Presence of voids on the surface and on finished margins result in poor fitting of the restorations. There are various causes of getting voids on the surface of the dies. Few of them are, low surface energy of impression materials causing difficulty to wet gypsum slurry causing air entrapment at surfaces of dies, advancing contact angle of die stone on impression material, bubbles in mixed die stone, technique of pouring the impression To overcome the entrapment of air in the mixed gypsum slurry, several methods have been proposed such as incorporation of non ionic surfactants in silicon impression materials to increase their wetability, plasma treatment or glow discharge in an argon atmosphere to increase the wetability, vacuum mixing of gypsum products, and use of mechanical vibrators (3). Die material is poured into the impression either manually or by using mechanical vibrators.

Material-flow into the impression depends on three factors.

1. Hydrophilic or Hydrophobic Nature impression material
2. Flow characteristics of die material
3. Vibrations during pouring.

The effect of vibration alone in pouring void free die can be studied by keeping Hydrophilic impression material and flow characteristic of die material constant, since the rate of flow of gypsum slurry in vertical direction and the spread in horizontal direction depends mainly poa the frequency and amplitude of the vibration[4].

Materials and Methods

a. Preparation of a metal die: The master die was machined in a shape of the frustum(5) from an aluminum rod of 28mm diameter. Vertical height of the die was 8.8mm including shoulder of I mm i.e. from base till the occluso-axil line angle. At the base, diameter of the die was 15.8mm including a shoulder of 1.6mm. 12.6mm was the diameter of the die at above I mm shoulder (Axio-gingival line angle). Convergence of 3.470^0 was given from the base to get a diameter of 11.6mm at occlusal end of the die

Frustum: A Part of a solid, such as a cone or pyramid, between two parallel planes cutting the solid, especially, the section between the base and plane parallel to it.

b. Preparation of custom tray: Custom tray of 2mm thickness for making polyvinyl siloxane impression of the master die was fabricated in auto polymerizing resin (Figure 2). Spacer of 2mm thickness and tray at the cervical portion was ensured for correct positioning of the tray and to get uniform material thickness. Horizontal trays handle of dimension 2mm thickness, 6mm width and 16mm length was fabricated for easy placement and removal of tray. Holes were made on the surface of the custom tray by straight fissure bur of 3mm dimension (diameter)[6.]

Holes were made at equal distance on the surface of the tray for retention of impression material. A total number of 100 custom trays were fabricated in such a way.

c. Making Hydrophilic polyvinyl siloxane impression: Each custom tray was checked for correct positioning on master die. Before making of impression, tray adhesive (DETERY CAULK) was apply on the inner surface and periphery of custom tray as recommended by manufactures[7.] Hydrophilic impression Material (REPROSIL®) of medium consistency was proportioned on a glass slab and was mixed with a mixing spatula for 30 seconds still uniform colour of impression material was achieved(8). After getting the desired consistency, the impression material was filled in the custom tray. Custom tray was then placed on the master die till the vertical stop was achieved. Custom tray was held undisturbed till the final set of the impression material. After final set of the material the custom tray was removed in one Jerk by holding the tray handle. The impressions were examined thoroughly and the defective impressions were discarded. The impressions aged by 20minutes bench set before pouring them. A total number of 100 impressions of the master die were made.

d. Pouring of impression: After making impressions, impressions were aged by 20 minutes bench set before making a cast. 100 grams of die stone was weighed nearer + 0.1 gram and 20ml of water was measured to the nearest 0.1 ml. The distilled water was placed in clean mixing bowl first, then the powder was added and (Quickly incorporated by hand spatulation) allowed to soak and then spatulated for 10 seconds with a clean rounded steel blade spatula. Then again spatulated in a mechanical vacuum spatulator (Multi vac 4, Degussa®) for 20 seconds to obtain a creamy bubble free mix.

A spatula was used to place the mixed die stone onthe periphery of the impression; vibration frequency and amplitude of mechanical vibrator was set before pouring the impression. With the impression held on the vibrator in tilted position the mixed die stone was carefully placed on the periphery of the impression to flow into the deepest portion. Additional increments of mixed die stone were added over the periphery of the impression until the impression was covered over period of 30 seconds.

With the vibration frequency set at 3000 cycles/min (low frequency), 10 impression were poured for each of the 5 amplitude steps and 6000 cycles/min (High frequency) 10 impressions were poured for each of the 5 steps of amplitude, so the total 100 impressions were poured. The values for amplitudes are presented (Table 1) as follows.

Table 1: Empirical Values for Amplitude

Steps	Amplitude in mm for frequency 3000 cycles/min	Amplitude in mm for frequency 6000 cycle/ min
1.	0.6mm	0.2mm
2.	0.8mm	0.3mm
3.	1mm	0.4mm
4.	1.6mm	0.6mm
5.	2mm	0.9mm

After pouring impressions, the dies were allowed to set for 1 hour. And die was removed from the impressions and allowed to dry on the table top. The casts were numbered for identification and distribution.

e. Die Evaluation: Stereoscopic Microscope (Bausch and Lomb) was used to examine each die with 10x magnification Die evaluation was done at Department of Material science at National Aerospace laboratory, Bangalore. Dies were examined for presence of voids. Total number of voids seen on the die surface were counted and recorded.

Results

After evaluation of each die the result were recorded both for low frequency (3000cycles/min-Table-2) and high frequency (6000cycles/min-Table 3). 10 samples were examined for each step of amplitude. Later means and standard deviation for each step of amplitude was calculated the results were as follows;

Table 2: Low frequency 3000 cycles/min

Steps	Mean	Standard Deviation
Step 1	4.5	±0.5
Step 2	4.9	±1.7
Step 3	6.6	±1.115
Step 4	6.8	±2.6
Step 5	8	±2.66

Table 3: High frequency (6000 cycles/ min)		
Steps	Mean	Standard Deviation
Step 1	3.3	±0.54
Step 2	2.1	±0.45
Step 3	1.7	±0.67
Step 4	3.4	±0.48
Step 5	3.7	±0.67

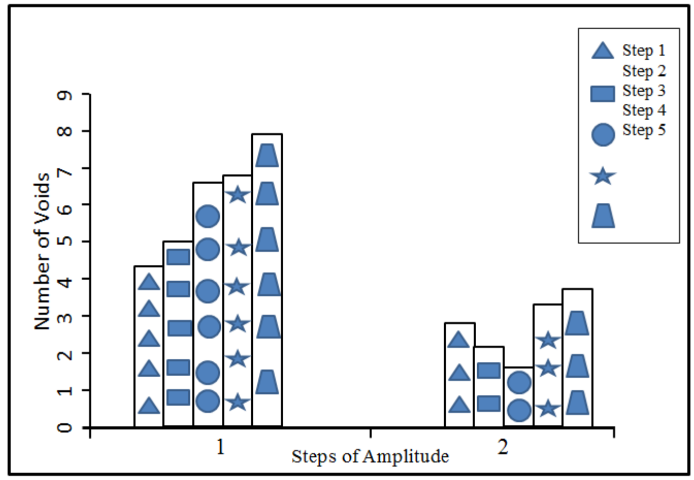
The mean and standard deviation for the voids on the cast surface poured from polyvinyl siloxane impressions with low (3000 cys/min Table 4) and high 6000 cys/min Table 5) frequencies of vibration and different steps of amplitude of vibration are presented in graph (Graph 1).

Table 4: Low frequency 3000 cycles/min		
Steps	Mean	Standard Deviation
Step 1	4.5	±0.5
Step 2	4.9	±1.7
Step 3	6.6	±1.115
Step 4	6.8	±2.6
Step 5	8	±2.66

Table 5

Table 3: High frequency (6000 cycles/ min)		
Steps	Mean	Standard Deviation
Step 1	3.3	±0.54
Step 2	2.1	±0.45
Step 3	1.7	±0.67
Step 4	3.4	±0.48
Step 5	3.7	±0.67

Means for voids in all dies groups calculated for low frequencies indicated that an increase in the magnitude of amplitude caused an increase in the number of voids on the die surface and means for voids in all dies groups calculated also for high frequencies indicated that at very low amplitude i.e., for step 1 there is increase in number of voids as the amplitude is increased i.e., for step 2 and 3 there in decreased in number of voids in steps respectively and as the amplitude of vibration increased further there is again increase in number of voids on die surface i.e., for step 4 and 5.



Graph 1

Two-way ANOVA was performed to establish whether there is any difference between low and high frequencies of vibration (Table-6). Results indicated that frequencies, group and their interaction among them were significantly different (P<0.0010 <0.001 and <0.001 respectively) because the interaction effect was significant.

Table 6: Two way ANOVA for Frequency And Amplitude Of Vibration					
Source of Variation	DF	Sum of Square	Mean sum of square	F	P. Value
Amplitude	4	72.44	18.11	17.60	<0.0001
Frequency	1	269.0	269.0	261.4	<0.0001
Frequency and amplitude	4	34.84	8.710	8.465	<0.0001
Residual	90	92.60	1.023		
Total	90	468.88	296.849		

Factor 1 ANOVA was computed for each frequency (Table -7). Summarizes one-way ANOVA performed in the void data for low-frequency of vibration. Result indicates that the means of all 5 groups of dies prepared

with low vibration frequencies, is not the same (P<0.0001).

Table 7: One Way ANOVA of Mean Number Of Void With Low Frequency Of Vibration					
Source	Analysis of variation				
	DF	Sum of Square	Mean Sum of square	F	P. Value
Between groups	4	77.20	19.30	13.30	<0.0001
Within groups	45	65.30	1.451		
Total	49	142.5	20.751		

To determine whether the groups were different from each other, the Bonferroni multiple comparison tests were used (TABLE-8). Result showed that;

Table 8

Table 8: Bonferroni's multiple comparison test			
	Mean Diff.	t	P.Value
Step 1 vs Step 2	-0.5000	0.9281	P>0.05
Step 1 vs Step 3	-2.100	3.898	P<0.01
Step 1 vs Step 4	-1.900	3.527	P<0.01
Step 1 vs Step 5	-3.500	6.497	P<0.001
Step 2 vs Step 3	-1.600	2.970	P<0.05
Step 2 vs Step 4	-1400	2.599	P<0.05
Step 2 vs Step 5	-3.000	5.569	P<0.001
Step 3 vs Step 4	0.2000	0.3712	P>0.05
Step 3 vs Step 5	-1.400	2.599	P>0.05
Step 4 vs Step 5	-1.600	2.970	P<0.05

Step 1 significantly different from steps 3, 4, & 5.

Step 2 significantly different from steps 3 & 5.

Step 4 significantly different from steps 5.

All the groups' pairs were significant except pairs 1 & 2

The one-way ANOVA performed on the void data for high frequency of vibration, results indicated that the means of all 5 groups and dies prepared with high frequency of vibration are not the same (P<0.001) (Table-9).

Table 9: One Way ANOVA of Mean Number Of Void With highest Frequency Of Vibration					
Source	Analysis of variation				
	DF	Sum of Square	Mean Sum of square	F	P. Value
Between groups	4	30.08	7.520	12.40	<0.0001
Within groups	45	27.30	0.6067		
Total	49	57.38	7.7267		

Table 9

To determine whether the groups were different from each other the Bonferroni multiple comparison tests was used (TABLE-10) results showed that.

Table 10

Table 8: Bonferroni's multiple comparison test			
	Mean Diff.	t	P.Value
Step 1 vs Step 2	-1.200	3.445	P>0.05
Step 1 vs Step 3	0.4000	1.148	P<0.05

Step 1 vs Step 4	-1.200	3.445	P<0.05
Step 1 vs Step 5	-1600	4.593	P<0.001
Step 2 vs Step 3	1.600	4.593	P<0.001
Step 2 vs Step 4	0.0000	0.0000	P<0.05
Step 2 vs Step 5	-0.4000	1.48	P<0.05
Step 3 vs Step 4	-1.600	4.593	P>0.001
Step 3 vs Step 5	-2.00	5.742	P>0.00
Step 4 vs Step 5	-0.4000	1.148	P<0.05

Step 1 significantly different from steps 2,4,5.

Step 2 significantly different from steps 3

Step 3 significantly different from steps 4 & 5.

The results of the study indicate that, more number of voids are found in the 3000 cycles / min frequency of vibration and less number of voids are found in the 6000 cycles / min frequency of vibration.

Discussion

Presence of voids on the surface and on finished margins result in poor fitting of the restorations Preparation of void free dies is important in the construction of accurate die restorations because, the fit and ultimate clinical success of cast dental restorations is dependent upon the accuracy and completeness of die reproduction.

There are various causes of getting voids on the surface of the dies[9]

1. Low surface energy of impression material
2. Advancing contact angle of die stone on impression materials
3. Wetability i.e., poor wetting characteristics of impression materials.
4. Bubbles in mixed die stone
5. Technique of pouring the impression
6. Improper use of vibrators.

To overcome the entrapment of air in the mixed gypsum slurry, several methods have been proposed by the investigators.

Barry K and Noorling[3] suggested the adding of surfactant to the impression will definitely reduce the void formation in dies. E. Schelb[6] suggested the use of syringe to make bubble free cast under the influences of the vibrators. Fernandez CP[9] and Nikolas Vassilokos[8] used the paint brush to minimize to make the bubble free cast. According to them it is very effective. Vibrator has definite effect in minimizing the voids in the dies and was observed by MD. Aleem Abdulla [2].

There are 3 factors which are more important in making void free cast or dies;

i. Hydrophillic or Hydrophobic nature of mpression material
ii. Flow characteristic of die material.
iii. Vibrations during pouring.

The nature of impression material is important because the voids formation is mainly depend on the wettability of impression material and formation and contact angle between the impression material and die stone. In hydrophobic impression material the wettability is less and the contact angle formation is above 90°C between impression materials and die stone. So the voids in the die or cast will be more.

But in hydrophillic impression material, the wettability of impression material is more and contact angle between impression material and die stone will be less i.e., below 90°C so the voids on the die will be less. So, hydrophillic material will be the best for minimizing the voids in cast or die[10].

Flow characteristics of the Die material are also an important factor is minimizing the voids in the die or cast. This mainly depend upon the proper water powder ratio (W:P) and particle size of the powder. The regular uniform size particles will reduce the voids and irregular particle size of the powder will increase the voids. Flow of material will depend on the particle size.

Another technique used for making void free cast or die was use of vibration while pouring the impression. When vibration is induced in the metal plate of mechanical vibrator, the gypsum slurry placed at the top of an impression moves in a repetitive cycle that causes the gypsum slurry to flow along the wall of the impression in a vertical direction and spread in the horizontal direction. If the rate of spreading is equal or greater than the rate of vertical flow, there is less turbulence in gypsum slurry, as a result of which there is less chance for void formation in cast or die.

Theoretical consideration

Vibration is periodic motion namely one that repeats over and over again in more or less equal time intervals. Here, one simple example was shown to understand what is frequency and amplitude. A vertical spring one end of which was fixed and the other end the mass was hanging from it. If the mass (M) was stretched down to stretch the spring and it is then relieved (Figure 1 & 2).

The mass vibrates up and down or moves in a simple harmonic motion (a) A pen is attached to the mass (M) and while the mass in is motion, a sheet paper is moved horizontally[6] Pen traces a simple harmonic motion in the form of waves. This simple harmonic motion in the form of waves is characterized by certain important properties. (Figure 3 & 4)

The maximum displacement from equilibrium position (x) is called the magnitude of vibration

i.e., amplitude The number of cycles a motion goes through per unit of time is called the frequency of vibration The vibrator which was used in this study has got frequencies of 3000 cycles/min and 6000 cycles/min used an electronic knob, so the electronics nob was

divided into two equal steps and amplitude in mm was measured using surface vibration sensor and oscilloscope and reading were recorded. In this study, the formation of voids on the die surface poured from polyvinyl siloxane impression material with a mechanical vibrator indicated a relation between the number of voids vibration frequency, and magnitude of amplitude. When vibration is induced in the metal plate of a mechanical vibrator, the gypsum slurry placed at the top of an impression moves in a repetitive cycle that cause the gypsum slurry to flow along the walls of the impression. The rate of flow of the gypsum slurry bears a strong resemblance to the periodic motion (vibration) of the metal plate.

Void formation may be explained on the basis of the rate of pouring, that is the rate of flow of the gypsum slurry in a vertical direction along the walls of the impression and the rate of spreading in the mold in a horizontal direction. If the rate of spreading is equal or greater than the rate of vertical flow, there is less turbulence in the gypsum slutry, as a result of which there is less chance for void formation. However, if the rate of vertical flow is greater than the rate of spreading, then there is a possibility of increase turbulence in the material that will result in more void formation.[11]

At low frequency of vibration, the metal plate of the mechanical vibrator vibrates more violently.

However, if the frequency of vibration is increased from zero to infinity, the metal plate may almost appear stationary and the gypsum slurry will not respond to the exciting vibration. Consequently, the rate of flow of the gypsum slurry is greater at low frequency of vibration than high frequency of vibration. The results of this study indicated the disadvantage of pouring an impression at low frequency (3000 cycles/min) as a method of reducing the voids in a dies. The means for the voids of the 5 groups of dies poured with low frequency of vibration was significantly higher (p<.001) than the means for voids of the 5 groups of dies poured with high frequency (Table-9). Furthermore, the dies poured with low frequency of vibration showed an increase in the means for the voids associated with an increase in the magnitude of amplitude of vibration (Graph I. and Table-9). And the means of high frequencies of vibration showed that at very low amplitude i.e., for step 1 there is increase in number of voids as the amplitude is increased i.e., for step 2 and 3 there is decreased in number of voids in steps respectively and as the amplitude vibration increased further there is again increase in number of voids on die surface i.e., for step 4 and 5 (Table-9). This finding may be due to the fact that the energy is proportional to the square of amplitude; therefore, more energy is transmitted to the gypsum slurry, causing it to flow at a faster rate. When the rate of flow of the gypsum slurry is greater than the rate of spreading, there is a greater chance of void formation.

Conclusions

Within the framework of this study the following conclusions can be made;

- The frequency and amplitude of vibration have a definite relationship in the formation of voids in dies, (type IV die stone) poured from polyvinyl siloxane impression material.
- Fewer voids were observed at frequency 6000cycles/min at an amplitudes of 0.4mm i.e.,step 3 amplitude.
- More number of voids were observed at frequency 3000 cycles/min at an amplitude of 2mm i.e., step 5 amplitude.
- According to this study, it is not advisable to pour the impressions at low frequency (3000cycles/min) of vibration as maximum voids were found at this frequency.
- It is recommended that the impression should be poured at frequency of 6000cycles/min and amplitude of step of 3 (0.4mm) to reduce the number of voids in dies.

References

1. Oh Y, Lee D, Hwang S, Kim K, Kim K. Effect ofnon-ionic surfactants on surface properties of hydrophilic polyvinyl siloxane impression materials. Colloids and Surfaces A: Physicochemical and Engineering Aspects2003;229(1-3):9-17.
2. Abdullah M. Effect of frequency and amplitude of vibration on void .formation in dies poured from polyvinylsiloxane impressions. The Journal of prosthetic dentistry 1998;80(4):490-4.
3. Norling B, Reisbick M. The effect of nonionic surfactants on bubble entrapment in clastomeric impression materials. The Journal of prosthetic dentistry 1979;42(3):342-7.
4. Bailey J, Donovan T, Preston J. The dimensional accuracy of improved dental stone, silverplated, and epoxy resin die materials. The Journal of prosthetic dentistry 1988;59(3):307.
5. Chaffee N, Bailey J, Sherrard D. Dimensional accuracy of improved stone and epoxy resin die materials. I. Single die. Journal of Prosthetic Dentistry (USA)1997,77(2):131-5.
6. Schelb E, Mazzocco C, Jones J, Prihoda T. Compatibility of type IV dental stones with polyvinyl

siloxane impression materials. The Journal of prosthetic dentistry1987;58(1):19.

7. Schelb E. Using a syringe to make void-free casts from elastomeric impressions. The Journal of prosthetic dentistry1988;60(1):121
8. Vassilakos N, Femandes C. Surface properties of elastomeric impression materials. Journal of Dentistry 1993;21(5):297-301.
9. Fernandes C, Vassilakos N, Nilner K. Surface properties and castability of elastomeric impression materials after plasma cleaning Dental Materials 19928(6):354-8.
10. Panichuttra R, Jones R, Goodacre C, Munoz C, Moore B. Hydrophilic poly (vinylsiloxane) impression materials: dimensional accuracy, wettability, and effect on gypsum hardness. The International journal of prosthodontics;4(3):240.
11. Chong Y, Soh G, Setchell D, Wickens J. The relationship between contact angles of stone on elastomeric impression materials and voids in stone casts. Dental Materials1990;6(3):162-6.