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Comparative Evaluation of Processing Accuracy between Compression Molded and Injection Molded Complete Dentures- An In Vitro Study

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Original Article

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ABSTRACT

Statement of Problem: A clinically significant incisal pin opening may occur after processing complete dentures if a compression molding technique is used. To obtain the proper vertical dimension of occlusion, a time-consuming occlusal adjustment is necessary that often destroys the anatomy of the artificial teeth. A new injection molding process claims to produce dentures that require few, if any, occlusal adjustments in the laboratory after processing.

Purpose: The purpose of this in-vitro study was to compare the dimensional accuracy by comparing the incisal pin opening of dentures fabricated by compression and injection molding techniques.

Material and Methods: Forty sets of complete maxillary and mandibular dentures were fabricated using two different molding techniques and grouped them as:- **Group 1**(control):- Twenty sets using compression molding technique and **Group 2:**- Twenty sets using an injection molding technique. Incisal pin opening was measured with a micrometer. Data were analysed statistically using an independent t-test.(p=0.00)

Results: A significant difference was found in pin opening between groups (t-test). However, analysis of vertical dimensional changes disclosed significant differences between the groups.

Conclusion: The injection molding method produced a significantly smaller incisal pin opening over the standard compression molding technique. The injection molding technique, using polymethyl methacrylate, was a more accurate method for processing dentures.

Keywords: Compression Molding, Injection Molding, Incisal, Pin Opening, Polymethyl Methacrylate(PMMA).

International Journal of Drug Research and Dental Science
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Introduction

The prevalence of edentulism varies worldwide which internationally is between 7% and 69% of the adult population, while in India prevalence of edentulousness is 19%. This state of edentulousness is a matter of concern to the majority of such population and is alleviated by the replacement with an artificial substitute such as a removable prosthesis which is fabricated using acrylic resin, metal, and nylon-based plastic as denture base materials. Even with the availability of the above-mentioned denture base materials, there is a constant struggle to find a suitable denture base material. The denture base acts as an intermediate medium between teeth and the jaw to transfer all or part of the masticatory forces to the surrounding tissues. In addition, the denture base should possess mechanical properties such as good elastic modulus, high strength, low creep, and dimension stability.[1]

The historic development of these denture base materials has to lead it to the times when the dentures were carved from stone, ivory, bone, and wood to the latest polymers. Over the centuries, a variety of materials have been used for denture construction. The ideal denture base material should possess several key attributes, like biocompatibility, good esthetics, high bond strength with available denture teeth, radio-opacity, ease of repair, and should possess adequate physical and mechanical properties.[2]

By 1946, 98% of all denture bases were fabricated from polymethyl methacrylate (PMMA) or copolymers. The advantages of PMMA include excellent esthetic properties, adequate strength, low water sorption, low solubility, long-lasting color, lack of toxicity, facility of repair, and construction by a simple molding and processing technique.[3] Though it has many advantages but this material is not ideal in every respect. Many factors in the laboratory procedure can lead to the alteration of occlusion during the construction of complete dentures. These factors are related to the intrinsic characteristics of the materials and techniques and extrinsic potential errors made by the dental technician. As a result of the processing technique, incisal pin opening may occur after the conventional compression molding technique and this increase in the vertical dimension of occlusion (VDO) needs to be corrected.[4] To process dentures different techniques are used including compression molding, injection molding, and microwave processing, compression molding is the conventional technique described in textbooks on complete dentures.[4,5]

Despite the acceptance of compression molding for more than 60 years, attempts to maintain the occlusal contacts developed in the trial denture have necessitated a laboratory remount with occlusal correction. Many factors in the laboratory procedures can lead to alteration of the occlusion during the construction of complete dentures.[4] However, despite the widespread popularity of PMMA, the inaccuracies inherent with the use of PMMA as a denture base material include dimensional change during processing which is frequently due to polymerization shrinkage. Polymerization shrinkage has two main effects.[3] The shrinkage distorts the palate of a maxillary denture resulting in an inaccurate fit to the supporting tissues by increasing the gap between the denture base and underlying mucosa[3,6,7] and it affects the position of the teeth on maxillary and mandibular dentures, and thus the final occlusion of the dentures.[3] As a result incisal pin opening may occur and thus increases the vertical dimension of occlusion (VDO). A large incisal pin opening can create a time-consuming occlusal adjustment sequence that often results in the disfigurement of the anatomy of artificial teeth.[4]

Denture base resins and processing techniques have been modified with time to overcome the adverse effects of compression molding. ***Pryor*** in 1942 introduced the injection-molding technique.[7]In 1970 (IvoclarSchaan, Liechtenstein) introduced an injection-molding system with modified acrylic resin claiming a dimensionally stable denture; which is an exact replica of the denture-bearing area. In the injection molding technique, also

known as the injection pressing technique, a pre-proportioned capsule containing the polymer and the monomer is used. By means of a special flask with a funnel or sprue, the capsule contents are injected by a pressure piston into the mold cavity. The lower portion of the flask is warmed while pressure through the piston is maintained. It is assumed that polymerization starts from the bottom upwards to the top of the flask and the funnel. It is claimed that polymerization shrinkage in this method is continuously compensated for by a flow of material from the capsule.[5,8] A new injection system (Success system, Dentsply International, Inc, York, Pa.) claims to eliminate changes in VDO to produce dentures that require few if any, adjustments in the laboratory. The denture base material recommended by the manufacturer with this new injection system is PMMA Lucitone 199 (Dentsply International, Inc), which is mixed in a conventional manner and put in a special detachable plastic cartridge for the injection procedures.[4]

The purpose of this in vitro study was to compare the processing accuracy between compression molded and injection molded dentures by comparing the incisal pin opening of dentures after processing.

Materials and Methods

Preparation of Specimens: Forty sets of (20 sets with compression molding technique (**Group 1**) and 20 sets using injection molding technique (**Group 2**) complete dentures were fabricated.

Denture Fabrication for Group 1 and Group 2

Forty sets of Maxillary and Mandibular complete dentures were made. All the dentures were made on a dental stone cast. Stone casts were obtained from class 1 silicone mold as shown in the **Figure 1** (Acrasil, Zahn Dental Co Inc, Tauton, Mass.). The base of each cast was indexed with V-shaped notches before it was mounted on the articulator so that each denture could then be remounted in the same position on the articulator after processing. The laboratory remount procedure is often used clinically to measure processing errors as manifested by the separation of the incisal guide pin from the incisal guide table. Changes in the vertical dimension of occlusion during this study were measured with a micrometer shown in the **Figure 2** (dial Indicator -Mitutoyo Manufacturing Co., Ltd., Tokyo, Japan) attached to the incisal guide pin of an articulator as shown in the **Figure 3** (Hanau Wide Vue, Teledyne Hanau, Buffalo, NY) which is capable of registering changes of 0.1mm. Teeth arrangement was done using Acry Rock teeth with maximum intercuspation between mandibular central fossae-marginal ridges and maxillary lingual cusps. Complete maxillary and mandibular wax dentures were formed on the master cast using a base plate wax. The palatal base was adapted using a layer of base plate wax at a uniform thickness of 2.0mm measured with a wax caliper. As each waxed setup was completed, the incisal pin was examined to ensure that it was in contact with the incisal guide table at the selected vertical dimension of occlusion. After completion of the occlusal adjustment and immediately before removing each set of waxed test dentures from the articulator for the investing procedures, the articulator was positioned on the table of the measuring device and the micrometer (dial indicator) was set to zero. To separate each cast with its waxed denture from its mounting, a piece of the wax sheet was placed at the junction of the cast posteriorly and mounting gypsum and tapped sharply to seperate. After separating the mounting plates from the articulator and casts the dentures were processed and deflasked using two different molding techniques.

International Journal of Drug Research and Dental Science
Volume 3 Issue 2 (Page: 142-152), 2021 ISSN: 2582-0826

Figure 1: Edentulous Mould

Figure: 2 Micrometer (Dial Indicator)

Figure 3: Micrometer Attached to Incisal Guide Pin of an Articulator

1. Compression molding technique: Twenty waxed complete dentures were flasked (**Figure 4**) in metal flasks and dewaxing was done in the dewaxing unit under continuous pressure. The flasks were then washed off with warm water to ensure the complete removal of wax. A thin layer of separating media was applied. The proportionate amount of the monomer and the polymer of Lucitone 199 heat cure resin was taken in the mixing jar. Then it was thoroughly mixed for 1 minute. After attaining the dough forming time, the dough was thoroughly kneaded between the fingers, and the mould cavities filled. The flask was closed and trial closure was carried out using a hydraulic press. After removal of flash, the flask was then clamped and pressure maintained for 30 minutes to allow proper penetration of monomer into the polymer and then cured. The flask was bench cooled for at least one hour and then cooled to room temperature before being opened.

Figure 4: Flasking of Complete Dentures Using Compression Molding Technique

International Journal of Drug Research and Dental Science
Volume 3 Issue 2 (Page: 142-152), 2021 ISSN: 2582-0826

2. Injection molding technique: Twenty waxed complete dentures were placed in special flasks designed for the injection molding system as shown in **Figure 5** and **Figure 6**. After investing in a special flask, dewaxing was done by placing flasks in boiling water for 3 to 5 minutes to soften the wax. Flask was opened and flushed with clean boiling water to remove all the residue of wax. The Flask margin was checked and ensured that both flask halves fit together with an intimate metal contact. A thin coat of separating agent was applied to the model and allowed the model to dry completely. A cartridge of a suitable size was selected and silicone spray was sprayed on it, cartridge was then placed in a cartridge carrier which was then placed in an electric cartridge furnace used for softening of denture base material. The application of spray prevents the adhesion of the cartridge with the cartridge carrier and allows smooth separation. The dentures were flasked according to the manufacturer's instructions. For the curing process of the Lucitone199, the hydraulic pressure of 6 atm at 100°C was maintained for 55 minutes. A 10-minute cooling process using running water with a pressure of 6 atm was used before deflasking. Finally, there was a further l0-minute cooling period. Then, the dentures were deflasked (**Figure 7**). Immediately after deflasking, all investment material was removed from the teeth, and casts, along with the maxillary and the mandibular dentures, were remounted on the articulator. The articulator was repositioned on the table of the measuring device, and the amount of incisal pin opening was measured. (**Figure 8** and **Figure 9**). The descriptive statistics of incisal pin opening between two groups are given in **Table 1.**

Figure 5: CD Samples Ready to be Flasked in Special Flask Designed for Injection Molding

Figure 6: Special Flask under Hydraulic Pressure during Injection Molding

International Journal of Drug Research and Dental Science
Volume 3 Issue 2 (Page: 142-152), 2021 ISSN: 2582-0826

Figure 7: CD Samples after Curing using Injection Molding Technique

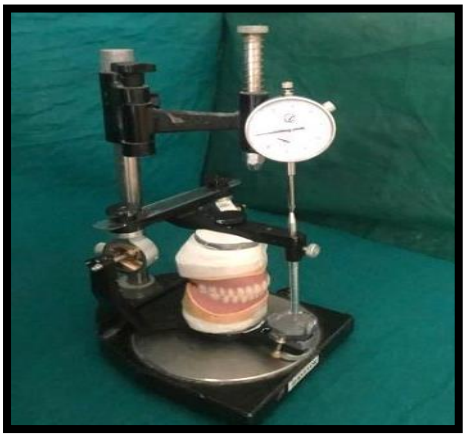


Figure 8: Articulator on measuring device with One of the Compression Molded Denture Showing Deflection on Micrometer

Figure 9: Articulator on Measuring device with One of the Injection Molded Denture Showing No Deflection on Micrometer

International Journal of Drug Research and Dental Science
Volume 3 Issue 2 (Page: 142-152), 2021 ISSN: 2582-0826

Results

The total no. of samples used was 40 acrylic dentures for the present study. **Table 1** presents descriptive statistics of incisal pin opening (increase in vertical dimension at occlusion) after processing with injection molding technique and compression molding technique.

Group	N	Mean (mm)	Std. Deviation	Std. Error Mean
Compression molding	20	0.980	.2627787	.0587591
Injection molding	20	0.280	.2092593	.0467918

N- Number of samples

Table 1: Descriptive statistics of incisal pin opening between both of the groups

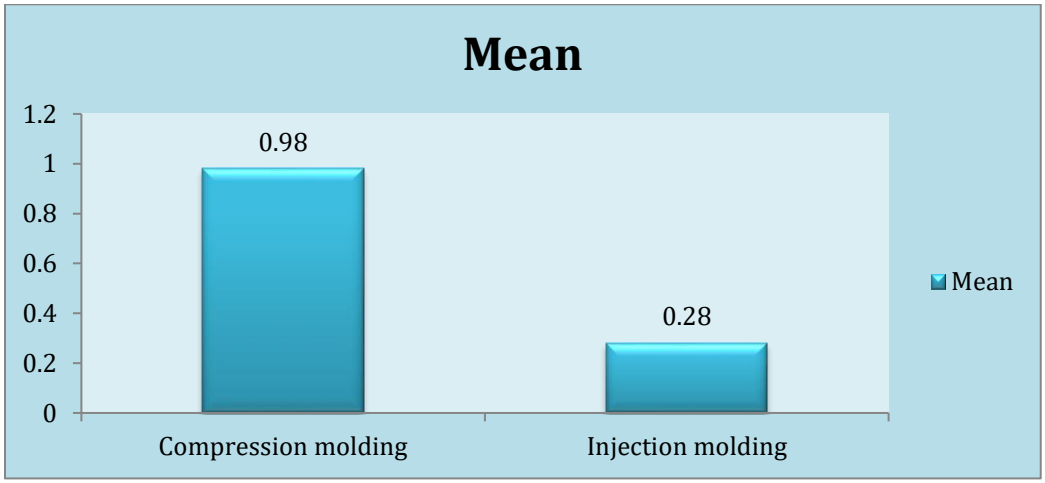
Mean values, standard deviation, and standard error mean of incisal pin opening (**mm**) obtained for injection molding technique as well as with the control group have been summarized in **Table 1** shown above**.**

Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference		t value	p value
		Lower	Upper		
0.700	0.0751139	.5479398	.8520602	9.319	0.00*
		.5476891	.8523109		

*statistically significant

Table 2: Intergroup Comparison of Incisal Pin Opening between both of the Groups.

T – Dependent t test value
p -significance value
This stats have been applied with a 95% confidence interval of the difference.
For the mean comparison of the two groups: *The dependent T-Test* test was applied. (T= 9.319, p =0.00*); maximum values with more increase in the incisal opening(VDO) were obtained with **compression molded dentures (0.980mm ± 0.262mm)**, and minimum values with less increase in the incisal opening were obtained for **injection-molded dentures (0.280mm ± 0.209mm)**.



Graph 1: Descriptive Statistics of Incisal Pin Opening between both of the Groups.

International Journal of Drug Research and Dental Science
Volume 3 Issue 2 (Page: 142-152), 2021 ISSN: 2582-0826

Discussion

Loss of teeth is a common phenomenon which is most significant among the geriatric population. Owing to the advances with continuous improvements in the medical domain, rapid increases in specialization and treatment modalities are observed in practice. So, it is realized that these improvements prolonged the life span of humans and drastically increased the life expectancy of elderly people within the past few decades.[9]

In the present study, the dentures were fabricated using two techniques. Immediately after deflasking, the maxillary and the mandibular dentures were remounted on the articulator, the articulator was repositioned on the table of the measuring device, and the amount of incisal pin opening was measured. The descriptive statistics of incisal pin opening between two groups are given in **Table 1** and **Table 2** given data indicates the intergroup comparison of an incisal opening between compression molded and injection molded dentures.

Forty measurements were observed representing 20 sets each of complete dentures processed by compression molding and injection molding methods. The mean increase in vertical dimension for the conventional compression method was 0.980mm with a standard deviation of 0.262mm. This increase compares favorably with the findings of similar studies done by Wesley RC et al.[10] and Woelfel Jb[11] The mean increase in vertical dimension for the injection method was 0.280mm with a standard deviation of 0.209mm. These results conflict sharply with the results of Garfunkel[12] whose results state that there is no significant difference between the two techniques, rather be more precise Garfunkel[12] concluded that vertical changes are greater in the injection pressing method. The mean Intergroup comparison of incisal pin opening between both of the groups was 0.700mm with a standard error difference of 0.075mm. A **dependent t-test** was performed to compare the means of the two groups and the computed t-value was 9.319 with a level of significance of p=0.00 which indicate that the difference between the two techniques was highly significant.

The results of the present study indicated a significantly higher degree of accuracy for the injection molding technique over the conventional compression molding processing technique which supports previous studies[4,13,14,15] conducted by Sergio S. Nogueira et al.[4], Strohaver RA[13], Sykora O, Sutow EJ[14], Anderson GC, Schulte JK, Arnold TG[15] Salim S, Sadamori S, Hamada T[16], that injection molding processing method is better than conventional compression molding method and results in little or no processing errors.

Nogueira et al.[4] compared the Success injection molding system (Dentsply International Inc, York, Pa.) with a compression flasking process by use of Lucitone 199 (Dentsply International Inc). The results revealed that the injection molding method produced a significantly smaller incisal pin opening over the standard compression molding technique when PMMA resin was used, that says the injection molding system is a better and more accurate system for processing dentures. According to the author, the significant difference between the two groups may be because the flash of resin that occurs in the compression molding technique is eliminated by the injection procedure.[4]

In a similar study[16], comparing injection molding with conventional compression as well as microwave polymerization of a nonanatomic model, the injection-molded technique showed less dimensional change than the other 2 methods, although the authors acknowledged the need to investigate anatomic dentures processed with teeth. Nelson et al.[17] compared conventional polymerization with microwave polymerization by use of the same packing technique (with a trail pack) for both groups of complete dentures. They demonstrated a significant difference between conventional polymerization, with an increase of the vertical dimension of occlusion of 0.146 mm (SD 0.068) and microwave polymerization of 0.628 mm (SD 0.128). Differences in materials may also exert an impact. A similar study[18] compared the dimensional change in

complete dentures fabricated by injection molding and microwave processing and found that all injection molding methods produced dentures with a slightly smaller increase in the vertical dimension of occlusion than the conventional method. Other studies[5,19-21] are in favour of the present study and revealed that the injection molding technique exhibited fewer processing errors than the compression molding technique with statistical significance.

One study[12] in contrast showed significantly no difference between the two techniques this may be because anatomic teeth were used, horizontal and anteroposterior movements might have influenced the amount of pin opening because of their changed contact with the contacting teeth. In a similar study conducted by Keenamet al[22] the denture bases fabricated by injection molding were found to have more expansion in vertical dimension than conventional heat curing technique.

Injection molding was introduced in dentistry in 1942 and was reported to compensate for the processing contraction of PMMA.[23] Several studies have supported this claim.[4,13-15,27] Other studies concluded that no clinically significant differences could be found between compression and injection molding techniques,[12,22,24] and a few studies actually reported better results with compression molding.[25,26] However, some of the studies reported greater dimensional accuracy with the injection molding technique used non-anatomic experimental models,[15,27] and others were based only on linear vertical measurements[4,13] and found significant changes (less incisal pin opening) with the injection molding technique. Processing deformation may be affected by the shape[14] and thickness[28] of the denture base, so the use of an anatomic model is warranted.[29] There is enough evidence available in dental literature supporting the present study wherein researchers have demonstrated the various advantages of injection molding technique over convention compression molding technique in terms of dimensional accuracy.[4,13,29, 30-32]

Conclusion

Within the limitations of this study, it can be concluded that:

- The injection molding technique exhibited fewer processing errors as compared to the compression molding technique with statistical differences (p=0.00).
- The injection molding method produced a negligible change in vertical dimensions as measured at the incisal pin, whereas the pack and press method (compression molding) produced pin opening many times greater with a statistical difference as measured by a t-test with a 95% confidence interval of difference.

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