Original Article

Evaluation of Three Different Processing Techniques in the Fabrication of Complete Dentures

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Abstract

Aims and Objectives: The objective of the present study is to compare the effectiveness of three different processing techniques and to find out the accuracy of processing techniques through number of occlusal interferences and increase in vertical dimension after denture processing.

Materials and Methods: A cross-sectional study was conducted on a sample of 18 patients indicated for complete denture fabrication was selected for the study and they were divided into three subgroups. Three processing techniques, compression molding and injection molding using prepolymerized resin and unpolymerized resin, were used to fabricate dentures for each of the groups. After processing, laboratory-remounted dentures were evaluated for number of occlusal interferences in centric and eccentric relations and change in vertical dimension through vertical pin rise in articulator. Data were analyzed using statistical test ANOVA and SPSS software version 19.0 by IBM was used.

Results: Data obtained from three groups were subjected to one-way ANOVA test. After ANOVA test, results with significant variations were subjected to *post hoc* test. Number of occlusal interferences with compression molding technique was reported to be more in both centric and eccentric positions as compared to the two injection molding techniques with statistical significance in centric, protrusive, right lateral nonworking, and left lateral working positions ($P < 0.05$). Mean vertical pin rise (0.52 mm) was reported to more in compression molding technique as compared to injection molding techniques, which is statistically significant ($P < 0.001$).

Conclusions: Within the limitations of this study, injection molding techniques exhibited less processing errors as compared to compression molding technique with statistical significance. There was no statistically significant difference in processing errors reported within two injection molding systems.

Keywords: *Compression molding, denture processing, injection molding*

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Introduction

Acrylic resins were first introduced to dentistry as denture base materials in 1937.[1] They had revolutionized denture base materials to the extent that in 1946, 98% of all denture bases were fabricated from polymethylmethacrylate (PMMA) or copolymers.[1] Research focused on denture base resins led to evolution of many advances such as vinyl resins, polystyrene, epoxy resins, polycarbonates, polyurethanes, and cyanoacrylates. Despite so many advances, PMMAs remain the material of choice for removable complete and partial edentulous prostheses. Low cost, relative ease of use, and reliance on simple

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processing equipment favored their popularity over other materials.[2]

Although popular for various reasons, PMMA exhibited dimensional changes which were found to be attributed to processing technique. Over the years, many advances took place in the processing techniques of resins such as compression molding, injection molding, and fluid resin techniques. To overcome the disadvantages of compression molding technique, injection molding technique of processing is introduced in 1942 by Pryor.[3] Studies have shown that change in vertical dimension is negligible with injection molding as compared to compression molding technique.[4,5] However, a careful comparison of these studies reported that the number of specimens in each experimental group varies and few studies have used anatomic models and remaining ones on nonanatomic models. Because of alteration in occlusal pattern of complete dentures after processing, processing errors will manifest as occlusal errors in centric or eccentric excursions and increase in vertical dimension as noticed from vertical rise of incisal pin. To overcome processing errors and avoid time-consuming laboratory remount procedure, research has been focused on denture processing techniques to find out the accurate processing technique that preserves the planned occlusal relation of waxed up dentures after processing. The present study is intended to compare the accuracy of three different processing techniques. Processing techniques are evaluated in anatomic patient models for number of occlusal interferences in centric and eccentric relationships and vertical rise of incisal pin after laboratory remounting. The present study was intended to evaluate postprocessing errors with three different processing techniques used in fabrication of complete dentures.

Materials and Methods

The present study was intended to evaluate the different processing techniques used in fabrication of complete dentures. Three different denture processing systems, compression molding, injection molding using prepolymerized resin, and injection molding using unpolymerized resin, were selected for the study.

Study population and sample size

A total sample of 20 patients was selected based on random sampling; however, as they were divided into three groups of 6 each, the final sample consisted of 18 patients. All 18 patients advised for complete denture treatment. The sample of 18 patients can be justified as the number of parameters recorded in each sample in all three groups exceeded more than 6. Based on previous studies,[4,5] the sample size of 18 can be justified, and as the number of parameters considered in patient was more in the present study, a conclusion was drawn that six patients in each group were sufficient for the study as the study was first of its kind clinically comparing all the three techniques for fabrication of dentures. Healthy patients with age ranging from 55 to 70 years with complete denture attending the Department of Prosthodontics were selected randomly for the study. A double-blinded method of sample selection was carried out. Ethical clearance was obtained from the Institutional Review Board and informed consent was obtained from the patients (Ethical Review Board of Sri Sai College of Dental Surgery, Vikarabad, Telangana [date 2/12/2008 letter no 270]). Inclusion criteria were completely edentulous patients, patients with Class I ridge relationship to facilitate teeth arrangement in balanced occlusion, and patients with adequate residual ridge to accept dentures with anatomic teeth. Residual ridges with tissue hyperplasia, inflammation or flabby ridges were not included in study. Exclusion criteria were absence of neuromuscular and temporomandibular joint disorders. The sample groups for the study were as follows:

- Group 1: Compression molding (DPI)
- Group 2: Injection molding prepolymerized resin (Bre.crystal thermoplastic resin, Bredent, Germany)
- Group 3: Injection molding unpolymerized resin (SR-Ivocap denture base resin, Ivoclar).

Complete dentures were fabricated using one of the three processing techniques for each group of sample.

Procedure

For each completely edentulous patient, after diagnosis and treatment planning, conventional procedure of complete denture fabrication was done. Anatomic teeth were selected for teeth arrangement (Acry Rock). Teeth arrangement was done with bilateral balanced occlusion making sure that simultaneous contacts of anterior and posterior teeth occur in both centric and eccentric relationships. Dentures of three sample groups were processed using one of the three different processing techniques. Denture processing was done according to the manufacturer's instructions for each processing technique.

After processing and deflasking, dentures were retrieved without separating from stone models. Dentures along with master casts were remounted on articulator making sure that no gap existed between cast and mounting indices. Fit Checker (GC dental, Tokyo) paste was mixed and placed on an incisal table, and an articulator was closed so that the incisal pin approximated incisal table. After material had set, elastomeric index was sectioned and the thickness was measured in the region

of indentation of incisal pin. Measurement was carried out using a digital Vernier calipers (Aerospace) with a sensitivity of 0.01 mm.

Articulating paper (Bausch) of 8 μ thickness was used to mark occlusal interferences in centric and eccentric relationships. All interferences were counted and noted separately followed by selective grinding. The Same procedure of laboratory remounting and occlusal error analysis was carried for all complete denture samples that were processed by different techniques. A number of occlusal interferences and measured vertical rise in incisal pin were tabulated and statistically analyzed to find out and compare the processing errors with each of three processing techniques.

Statistical analysis

Results obtained after complete denture processing by three techniques were subjected to one-way ANOVA test for variations in mean values of each sample group. After ANOVA test, results with significant variation were subjected to *post hoc* test to compare significance between three sample groups.

Results

For the compression molding technique in centric and eccentric position, the mean was 7.33 and 7.67, the mean vertical rise in pin was 0.52 [Table 1]. For injection molding – Bre.crystal in the right lateral working and nonworking sides, the mean values are 3.50 and 1.17, respectively; the mean vertical rise in pin was 0.25 [Table 2]. For injection molding – SR-Ivocap in left lateral working and nonworking sides, the mean values are 2.17 and 1.33, respectively; the mean vertical rise in pin was 0.08 [Table 3].

There is a significant increase in number of centric and protrusive interferences with compression molding technique when compared to two injection molding systems ($P < 0.01$) and no statistical significance is noticed between two injection molding systems ($P > 0.0.5$). In the right lateral working position, there is no statistical significance reported between three processing techniques in this position ($P > 0.05$). In the right lateral nonworking position, significant increase in the number of centric interferences is reported with compression molding technique when compared to two injection molding systems, and there is no statistical significance between two injection molding systems ($P > 0.05$) [Table 4].

In left lateral working position, there is a significant increase in number of centric interferences with compression molding technique when compared to two injection molding systems ($P < 0.05$) and no statistical significance is noticed between two injection molding systems ($P > 0.05$). In left lateral nonworking position, there is no statistical significance reported between three processing techniques in this position ($P > 0.05$). For vertical rise in pin, significant rise in incisal pin is reported with compression molding technique when compared to two injection molding systems ($P < 0.05$) and no statistical significance is noticed between two injection molding systems ($P > 0.05$) [Table 4].

Discussion

The present study evaluated compression molding, injection molding using prepolymerized resin, and injection molding using unpolymerized resin techniques for fabrication of complete dentures. The conventional method is the most applicable method for curing acrylic resin due to its simplicity and relatively good accuracy. Therefore, in various studies, this method has been considered the gold standard for comparison with other techniques. Among denture processing methods, injection

Table 1: Analysis of occlusal contacts after processing by compression molding technique

Compression molding technique	Study subjects (*n*)	Mean
Centric	6	7.33
Protrusive	6	7.67
Right lateral working	6	4.17
Right lateral nonworking	6	2.50
Left lateral working	6	4.50
Left lateral nonworking	6	2.33
Vertical rise	6	0.52

Table 2: Analysis of occlusal contacts after processing by injection molding - Bre.crystal

Injection molding - Bre.crystal	Study subjects (*n*)	Mean
Centric	6	3.83
Protrusive	6	4.67
Right lateral working	6	3.50
Right lateral nonworking	6	1.17
Left lateral working	6	2.33
Left lateral nonworking	6	1.17
Vertical rise	6	0.25

Table 3: Analysis of occlusal contacts after processing by injection molding - SR-Ivocap

Injection molding – SR-Ivocap	Study subjects (*n*)	Mean
Centric	6	4.67
Protrusive	6	4.33
Right lateral working	6	2.83
Right lateral nonworking	6	1.33
Left lateral working	6	2.17
Left lateral nonworking	6	1.33
Vertical rise	6	0.08

Table 4: Comparative analysis of occlusal contacts after processing by all three techniques

	n	Mean	SD	*P*	*Post hoc* test
Centric					
Compression molding technique	6	7.33	1.75	0.001	CMT > TP (0.001)
Injection molding - Bre.crystal	6	3.83	1.17		CMT > BPS (0.01)
Injection molding - SR-Ivocap	6	4.67	1.03		
Protrusive					
Compression molding technique	6	7.67	0.52	<0.001	CMT > TP (<0.001)
Injection molding - Bre.crystal	6	4.67	0.82		CMT > BPS (<0.001)
Injection molding - SR-Ivocap	6	4.33	1.37		
Right lateral working					
Compression molding technique	6	4.17	1.47	0.237	-
Injection molding - Bre.crystal	6	3.50	1.05		
Injection molding - SR-Ivocap	6	2.83	1.33		
Right lateral nonworking					
Compression molding technique	6	2.50	0.55	0.001	CMT > TP (0.001)
Injection molding - Bre.crystal	6	1.17	0.41		CMT > BPS (0.003)
Injection molding - SR-Ivocap	6	1.33	0.52		
Left lateral working					
Compression molding technique	6	4.50	2.07	0.016	CMT > TP (0.036)
Injection molding - Bre.crystal	6	2.33	0.82		CMT > BPS (0.024)
Injection molding - SR-Ivocap	6	2.17	0.75		
Left lateral nonworking					
Compression molding technique	6	2.33	1.21	0.074	-
Injection molding - Bre.crystal	6	1.17	0.41		
Injection molding - SR-Ivocap	6	1.33	0.82		
Vertical rise					
Compression molding technique	6	0.52	0.14	<0.001	CMT > TP (0.009)
Injection molding - Bre.crystal	6	0.25	0.15		CMT > BPS (<0.001)
Injection molding - SR-Ivocap	6	0.08	0.10		

ANOVA $P<0.05$. SD=Standard deviation, CMT=Compression moulding technique, TP=Thermopress, BPS=Biofunctional prosthetic system

molding has always been interesting for researchers because of compensation of polymerization shrinkage due to the pressure exerted by injection of the acrylic resin.[6-8]

In the present study, it was seen that the number of occlusal interferences for dentures processed with compression molding technique showed consistently more number of interferences in both centric and eccentric positions when compared to two injection molding techniques studied. This variation has statistical significance in centric, protrusive, right lateral nonworking, and left lateral working positions ($P < 0.05$) and no significance in the right lateral working and left lateral nonworking positions ($P > 0.05$). This indicates the accuracy of injection molding techniques over compression molding technique within the limits of samples tested. When Bre.crystal and SR-Ivocap injection molding systems were compared, mean number of interferences for Bre.crystal injection molding system was more in protrusive, right, and left lateral working positions and less in centric, right, and left lateral nonworking positions. Although variation in number of interferences was reported between two systems, it was found to be statistically insignificant ($P > 0.05$). From this comparison, it was revealed that there was not much variation in interferences within two of the injection molding systems.

These results for number of interferences give an indication of minimal three-dimensional positional changes of teeth with injection molding technique as compared to compression molding technique. The results indicating the advantages of injection molding systems over compression molding system were coinciding with several studies that have been done to compare processing errors between compression and injection molding techniques.[9-12] The criteria for assessing processing errors were different for different studies when compared to number of interferences used in the present study. These results were in contradiction with the study done by Grunewald *et al*.,[13] who independently investigated Pryor's[3] injection molding technique and found no significant advantages over conventional packing techniques. However, this study was published in 1952 before the introduction of newer injection molding systems.

Dentures processed by compression molding technique showed a mean pin rise of 0.52 mm, which was significantly more when compared with two injection molding systems ($P < 0.001$). Among the two injection molding techniques, Bre.crystal dentures produced a mean of 0.25 mm pin rise, when compared to SR-Ivocap dentures which produced a mean of 0.08 mm. This indicates that change in vertical dimension of occlusion was more for dentures processed with compression molding technique when compared to injection molding technique which was statistically significant ($P < 0.05$). When two of the injection molding techniques were compared, this change was more for Bre.crystal injection molding technique when compared to SR-Ivocap injection molding technique, although statistically insignificant ($P > 0.05$). A processing error of <1 mm can be easily correctable, but an error of >1 mm was difficult and undesirable.[14] The pin rise with all three systems used in this study was well within this range.

A few studies were contradicting the results from the present study. A study by Hardy[15] on dentures processed with compression molding technique reported an average pin opening of 2.3793 mm, which was well above the recommended range. Garfunkel[12] compared compression molding and SR-Ivocap injection molding techniques and reported more pin opening for SR-Ivocap system which was almost twice when compared to compression molding system and was not coinciding with the present study. These differences in pin rise reported from various studies may be because of variations in samples tested, materials used for processing, technical specifications, and methods used for measurements that were followed by different researchers.

Statistically, significant difference was reported between compression and injection molding techniques (both Bre. crystal and SR-Ivocap), and among the two techniques, injection molding technique was shown to exhibit more accuracy which could be because of various advantages offered by this system, which includes (1) continuous injection of material with a reservoir of resin which compensates for processing shrinkage, (2) absence of resin flash between the compartments, (3) absence of residual stresses with injection molding systems, (4) well-controlled and proportioned polymer to monomer ratio (SR-Ivocap system) and (5) use of prepolymerized resin (Bre.crystal system).

Variations reported within two injection molding systems may be because of difference in material used in two systems (prepolymerized PMMA without the use of monomer in Bre.crystal resin compared to unpolymerized SR-Ivocap material in which polymer to monomer ratio and mixing was standardized using prefabricated cartridges that are mechanically mixed). Nature of the resin and differences in polymerization shrinkage also might have contributed to these variations although they were statistically insignificant.

Strengths

Most of the studies reported in literature till date in the context of denture processing and movements of teeth were *in vitro* studies, and an attempt was made to combine *in vivo* procedure of denture fabrication till jaw relation stage and *in vitro* analysis of interferences. Comparison was made among the most commonly use materials in current day-to-day practice.

Limitations

As this study is an *in vivo* study that was conducted on completely edentulous patients with dentures, there were variations in the area of denture bearing surface and residual ridge forms. These factors may alter the amount of resin used for each denture, thereby affecting amount of polymerization shrinkage which may be one of the causes of inaccuracy. It was minimized by considering size of the ridge during sample selection. The study should be done on larger sample of edentulous patients to conclude the accuracy of results.

Summary and Conclusions

Within the limitations of this study, injection molding techniques exhibited less processing errors as compared to compression molding technique with statistical significance. There was no statistically significant difference in processing errors reported within two of injection molding systems. Future research as a continuation of the present study needs to be done to evaluate interferences *in vivo* in patient's oral cavity. Future research as a continuation of the present study needs to be done to evaluate interferences in vivo in patient's oral cavity to evaluate the comfort levels and chewing efficiencies comparing dentures processed with different techniques.

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Conflicts of interest

There are no conflicts of interest.

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