Comparison of vertical changes and linear accuracy of complete dentures produced by conventional and injection molding techniques

May Zin Oo[1], Thiri Kyaw[2], Kyaw Tint[2]

1. Dental Department, Sao San Tun General Hospital, Taunggyi, Myanmar
2. Department of Prosthodontics, University of Dental Medicine, Mandalay, Myanmar

Received Oct 23, 2020; Accepted Nov 21, 2020

Abstract

In complete denture treatment, vertical changes and linear accuracy due to processing error are inevitable when making with conventional molding technique. The greater the errors, the more time will be consumed to correct the occlusal relationship by selective or corrective grinding. In case of severe vertical errors, the grinding process also requires grinding of the teeth beyond the cusps, thereby destructing anatomical features of the teeth. The purpose of this study was to compare the vertical changes and linear accuracy of complete dentures produced by conventional and injection molding techniques. Twenty two maxillary and mandibular complete edentulous patients at the Department of Prosthodontics, University of Dental Medicine, Mandalay were divided into two groups by blocked randomization methods. Dentures were produced by conventional molding technique for group A and by injection molding technique for group B. Dentures of both groups were made by using heat cure Polymethylmethacrylate (PMMA) QC20 (Japan).. The linear dimensions and amount of incisal pin opening were measured with digital slide clipper (accuracy ± 0.03 mm). Data were analyzed by Mann-Whitney U test. There was statistically significant increase in vertical dimension of denture produced by conventional molding technique than injection molding technique ($P<0.05$) but there was no significant difference in linear accuracy. Within the limitation of this study, the injection molding technique produced more accurate denture especially in vertical dimension when PMMA was used. Further studies are needed to assess dimensional changes of denture in long term use and to evaluate the comfort levels and chewing efficiencies with dentures produced by these techniques.

Keywords: complete denture, conventional molding technique, linear accuracy, vertical dimension, Injection molding technique

Introduction

Complete denture is prescribed to restore the masticatory functions and esthetics. A successful denture should have stability in vertical dimension, linear accuracy in order to increase chewing efficiency, increase patient's comfort and prevent injury to the oral tissue [1]. Type of materials used in fabrication of denture base affect the dimension during denture processing and other factors related to clinical use [2].

There was a variety of denture base materials. Formerly used materials were

Correspondence: Dr. May Zin Oo,
1F, Gandamar Hostel. Sao San Tun Hospital, Taunggyi, Myanmar
Email: mayzinoo16.dr@gmail.com

Valcanite (vulcanized rubber), Bakelite, Cellulose nitrate, Nylon, Epoxy resins, Vinyl polymers (poly vinyl chloride, poly vinyl acetate and polystyrene), Polycarbonates [3].

Heat cure polymethylmethacrylate (PMMA) was introduced as the denture base material in 1937. Today, it is used as the majority of denture base material because of its excellent properties such as excellent esthetic, low water sorption, low solubility, lack of toxicity and facility of repair. However, it has some inaccuracies such as dimensional changes during processing due to polymerization shrinkage, incorrect water powder ratio and inadequate compaction pressure [4].

Polymerization shrinkage distorts the palate of the maxillary denture resulting in an inaccurate fit and the final occlusion of the denture [5]. To overcome this problem acrylic resins have been modified to improve not only their physical and chemical properties but also their working properties of complete denture4. Despite the acceptance of compression molding technique was the conventional technique for more than 60 years; this technique has some significant disadvantages such as increased vertical dimensions, spherical deformation and higher amount of residual monomer [6].

These factors are related to intrinsic characteristics of the materials and techniques and extrinsic potential errors made by the dental technicians or dentist. Metal rim to rim contact of flask can't be achieved exactly because of the separation of flask during flasking and packing. This separation can cause increased thickness of acrylic base of denture. The dimensional changes due to flask design and polymerization shrinkage can cause the incisal pin opening during laboratory remount procedure and increased occlusal vertical dimension (OVD) in the patient mouth. Increased OVD can cause discomfort, trauma, loss of freeway space, clicking teeth, elongation of face and expression of strain. So it is needed to be corrected and this may cause time consuming, disfigurement of anatomical form of teeth and discomfort to the patient. 'A large incisal pin opening can cause time consuming by occlusal adjustment and can lead to disfigurement of the anatomy of artificial teeth in severe incisal pin opening [7].

To overcome this problem, Pryor introduced an injection molding technique in 1942 [8]. Also Grunewald et al studied Pryor's technique and they reported no significant difference between two methods [9]. In 1970, Ivoclar (Schaan, Liechtenstein) introduced a new injection molding system. Several injection systems are now available and each claimed to produce more accurate denture base. In injection molding technique, the flask design is difference. It is made with aluminium and contained 4 bolt nuts to screw tightly. So the separation of flask could not occur during flasking and packing. Therefore it can give more dimensionally accurate denture. The injection molding technique has proved its advantages during the years: precise adaptation of acrylics to master cast, continuous compensation of acrylic shrinkage due to inflowing acrylic material and constant high pressure during the whole polymerization process, better physical properties of denture, lower porosity and high degree of homogeneity. Patient's comfort is guaranteed by the precise fit of the acrylic dentures as well as minimum level of residual monomer.

Although many researchers studied about the injection and compression molding techniques, some researchers studied the specimens without teeth. Some studied with teeth but those studies were in vitro study except Chintalacheruvu et al. Chintalacheruvu studied the SR Ivocap injection system in vivo. The present study is about the Snow Rock injection system in vivo. The present study may help to know

how accurate denture will be produced by Snow Rock JetPcck injection machine (DK MUNGYO, Korea) by comparing changes in the vertical dimension and linear accuracy of complete dentures processed by the conventional and injection molding techniques.

The purpose of this study is to evaluate and compare which method is better in accuracy between these two methods.

Materials and methods

Twenty-two fully edentulous patients attending to the Department of Prosthodontics, University of Dental Medicine, Mandalay were selected according to selection criteria. These patients were divided into two groups by blocked randomization methods. Group A got the denture produced by convention technique and group B got denture produced by injection technique. Dentures of both groups were made by using heat cure Polymethylmethacrylate (PMMA) QC20 (Japan). The linear distance and vertical height of incisal pin were measured in the wax denture immediately before investing. The vertical dimension was measured by using digital slide clipper. The master cast was separated from the articulator and cover screws was inserted at palatal base plate of wax denture to be use as reference points for measuring linear distance. One reference point (point A) was at the midline of canine papilla canine (CPC) line. The other two points point B and C) were attached at distal to second molar on each side of wax denture. The linear distance was measured in the wax denture immediately before investing. The measurement at the wax stage was use as the base line reading record (figure 1).

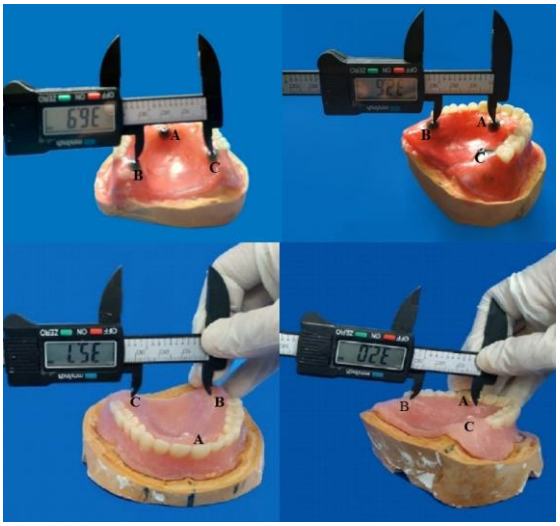

Figure 1. Measurement of linear accuracy in wax denture (upper panels) and in acrylic denture after processing (lower panels) with digital slide clipper

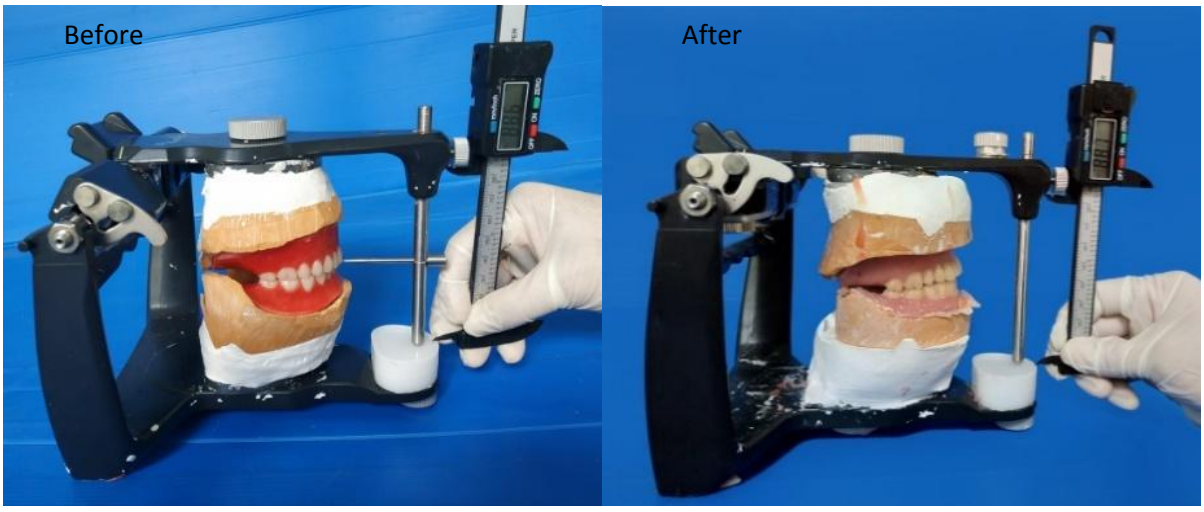

Figure 2. Measurement of vertical dimension with digital slide clipper before and after processing.

For group A, wax denture was processed by conventional molding technique and for group B was done by injection molding technique. After deflasking, measure the linear changes in 3 dimensions (A-B), (B-C), (C-A) for each conventional and injection molded maxillary denture with slide clipper. Each denture was remounted in the same position on the articulator and then measured the separation of incisal guide pin from the incisal guide table with digital slide clipper and register the changes (figure 2). Data were analyzed by Mann-Whitney U test.

Results

The mean value of pin opening in injection molding technique was (0.55) and the mean value of pin opening in conventional molding technique was (1.14). Significant different could be found in pin opening of dentures between conventional and injection molding technique (P value =0.023). The conventional molding technique showed more vertical dimensional change than injection molding technique (Figure 3).

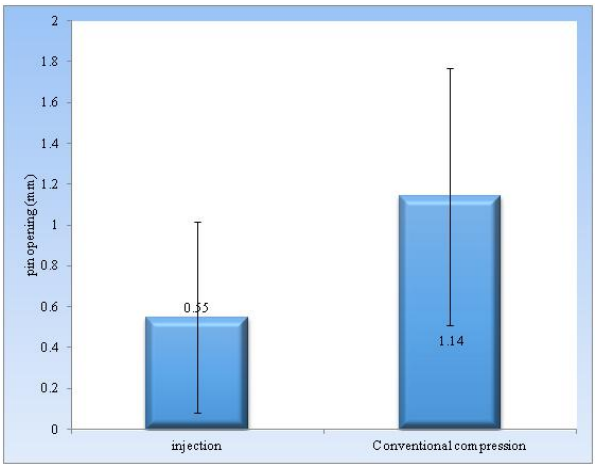

Figure 3. Comparison of mean pin opening of dentures produced by conventional and injection molding technique. Mann-Whitney U test was used (P value= 0.023). Error bars denote standard deviation

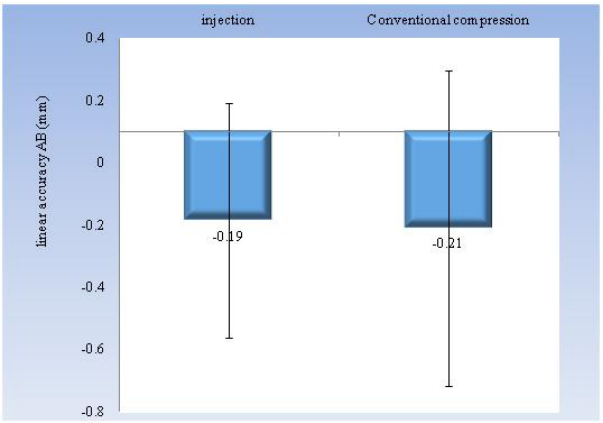

Figure 4. Comparison of mean linear accuracy of denture in dimension A-B of dentures produced by conventional and injection molding techniques. Mann-Whitney U test was used (P value = 0.748). Error bars denote standard deviation.

The mean change in denture base distance values in injection molding technique were A-B (-0.19 mm), B-C (-0.12 mm) and C-A (-0.14 mm) and the mean change in denture base distance values in conventional molding technique were A-B (-0.21 mm), B-C (-0.16 mm) and C-A (-0.38 mm). There is no significant different could be found in linear change of denture base between conventional and injection molding technique. For A-B (P value = 0.748), B-C (P value = 0.797), C-A (P value = 0.133) (Figure 4, 5 and 6)

The linear accuracy (A-B) of denture produced by conventional molding technique showed slightly greater than injection molding technique although there was no significant different. The standard variation bar of conventional molding technique was longer than injection molding technique. This means that the data of conventional molding technique were more variation than injection molding technique (figure 4).

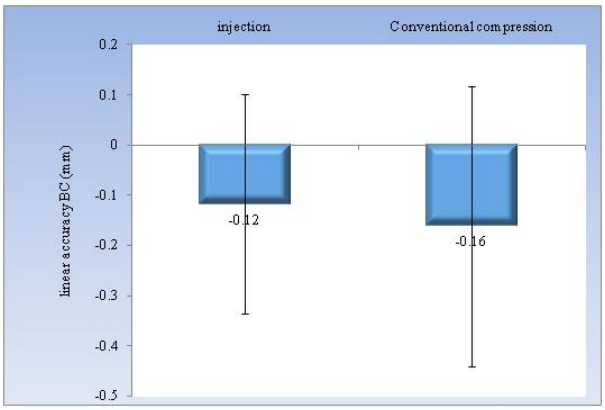

Figure 5. Comparison of mean linear accuracy of denture in dimension B-C of dentures produced by conventional and injection molding techniques. Mann-Whitney U test was used (P value= 0.797). Error bars denote standard deviation.

The linear accuracy (B-C) of denture produced by conventional molding technique showed greater than injection molding technique although there was no significant different. The standard variation bar of conventional molding technique was longer than injection molding technique. This means that the data of conventional molding technique were more variation than injection molding technique (figure 5).

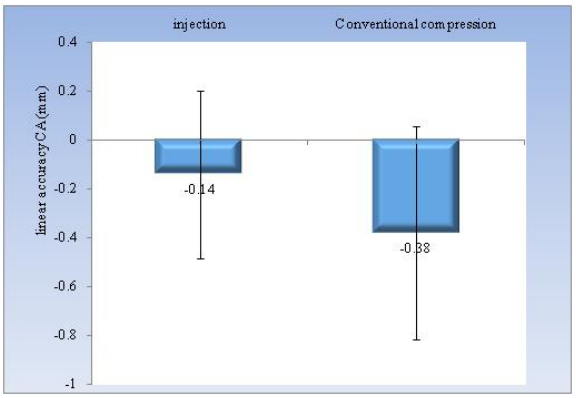

Figure 6. Comparison of mean linear accuracy of denture in dimension C –A of dentures produced by conventional and injection molding techniques. Mann-Whitney U test was used (P value= 0.133). Error bars denote standard deviation

The linear accuracy (C-A) of denture produced by conventional molding technique showed two times greater than injection molding technique although there was no significant different (figure 6).

Discussion

Processing errors can be caused by many factors before, during and after processing the denture. The greater the errors, the more time will be consumed to correct the occlusal relationship by selective or corrective grinding. The grinding process not only absorbs valuable time, but also in the case of severe openings, requires a grinding of the teeth beyond the cusps, thereby destructing the anatomical features of the teeth [10].

Vertical dimensional changes in pin opening

The conventional molding technique was greater dimensional changes than injection molding technique. Significant difference could be found in pin opening of dentures between conventional and injection molding techniques (P=0.023).

Pyeton and Garfunkel found that the amount of pin opening was high with the injection molding technique than compression [11]. This was because these studies were published before the introduction of newer injection systems.

According to the results of Nogueira et al. (1999) the pin opening of injection was 0.31mm and compression was 1.16mm and by the results of Philip, the pin opening of injection was 0.63mm and convention was 0.74 mm. The results of the present study were nearly same as these study results [7].

Strohaver (1989) reported the pin opening of injection molding technique was 0.02 mm and conventional technique was 0.66mm by using the SR Ivocap

system (Ivoclar USA Inc., San Marcos, Calif) and Microlon-LW heat cure acrylic resin [12]. Chintalacheruvu et al. (2017) also used SR Ivocap and the results showed 0.08 mm for injection molding technique and 0.52 mm for conventional molding technique [13]. The results of the present study were different from Strohaver and Chintalacheruvu et al study. This may be due to the different use of materials and injection machine system. In the present study, the injection system was Snow Rock JetPcck injection machine (DK MUNGYO, Korea) and QC 20 heat cure acrylic resin was used. In SR Ivocap system that was used by Strohaver and Chintalacheruvu et al, triturating of the liquid:powder system was mechanically performed in prepackaged capsule in attempt to produce more even mix resulting in homogenous denture base. The mixed resin was injected into the flask under continuous pressure during the processing. But in the Snow rock system, liquid: powder was hand-mixed and the dough resin was injected into the flask under continuous pressure.

In this study PMMA was used as denture base material because of its excellent properties such as excellent esthetic, adequate strength, low water sorption, low solubility, lack of toxicity, facility of repair and construction. However, it had some inaccuracies such as dimensional changes during processing due to polymerization shrinkage, incorrect water powder ratio and inadequate compaction pressure [4]. The polymerization shrinkage of resin may be the one reason for increase vertical dimension of denture.

Mould expansion during investment can be minimized by clamping the two halves of the second pour of the investment. In the present study the spring clamp was used to minimize the setting expansion by thermal cycle during the conventional molding. But the flasks used in the conventional molding technique could allow the mould expansion and cannot be obtained the exact metal to metal contact after deflasking to make dewaxing and trial closure.

The flasks used in the injection molding technique are made from aluminium and flask walls are thick. The two halves of flask are retained by four boll nuts. Therefore, mould expansion cannot cause metal separation. Injection molding allows directional control of the polymerization process through the flask design. So, the injection molding technique produced lesser amount of incisal pin opening than conventional molding techniques.

Grant and Atkison pointed out that the setting expansion of gypsum can also cause tooth movement during investing. Grant had showed tooth movement of 0.02 to 0.05mm resulting from the setting expansion of gypsum [14]. The types of investment material are also influencing change in position of denture teeth [10].

Linear Accuracy

Although there is no significant difference between two groups, the injection molding technique was more accurate in linearly than conventional molding technique.

Grunewald et al. (1952) used semi-anatomic denture bases without teeth, the result showed little differences in the pattern of contraction between injection and compression molding techniques [9]. Salim et al. (1992) had also done similar study comparing injection, conventional and microwave polymerization of a non-anatomic model, the injection molding technique showed less dimensional changes than the two others [15].

Gharechahi et al. (2014) studied the dimensional accuracy of resin block which produced with injection and conventional molding. He found that the injection molding technique produced dimensionally more accurate denture [16].

Anderson et al. (1988) used non-anatomic blocks to compare polymerization of injection and conventional molding technique avoiding variables present in denture teeth. The changes in all three dimensions in injection molding technique showed less dimensional changes than conventional molding technique and statistically significant. The absence of denture teeth in the sample eliminated the problems with tooth movement during investment and processing. The resulting dimensional changes were directly identifiable to the polymerization of the resin and the relative negligible dimensional changes of the investing stone. These results supported that the injection technique has less inherent processing shrinkage than conventional molding technique because the packing methods affect the polymerization of acrylic resin [17].

The present study found that the dentures produced by injection molding technique were more fine, homogenous and no porosity. The working time could save because the resin was injected at constant pressure and no need trial closure, and little grinding time needed at remount procedure. Injection molding technique has little disadvantages such as using stone in investing the denture that takes more time in investing procedure, more caution and time to deflasked and recover cured dentures. However, the injection molding technique produced more accurate denture than conventional molding technique.

The limitation of this study included small number of patients, the materials and machines needed to standardize the fabrication of denture and short curing method. Further studies needed to assess dimensional changes of denture in long term use and to evaluate the comfort levels and chewing efficiencies comparing dentures produced by these two techniques.

Conclusion

According to the results of this study, the injection molding technique produced significantly smaller vertical changes in denture over the conventional compression molding technique when PMMA was used although there was no significant difference in linear accuracy.

The injection molding technique would be recommended in fabrication of complete denture because the valuable time would be saved by reducing the errors which necessitates the grinding the teeth to correct the occlusal relationship.

References

1. Mardan N, Preoteasa CT, Imre M., Tancu AM, Preoteasa E. Self-reported denture satisfaction in completely edentulous patients. Romanian J Oral Rehab 2013; 5 (4): 88-95.

2. Arafa KA. Effect of different denture base materials and changed mouth temperature on dimensional stability of complete dentures. Int J Dent. 2016; 1-5.

3. Combe EC. Notes on dental materials (sixth ed.). Manchester: Grant. AA; 1992.

4. Parvizi A, Lindquist T, Schneider R, Williamson D, Boyer D, Dawson DV. Comparison of the dimensional accuracy of injection molded denture base materials to that of conventional pressure pack acrylic resin. J Prosthodont. 2004; 13(2): 83-89.

5. Woelfel JB, Paffenbarger GC. Method of evaluating the clinical effect of warping a denture: report of a case. J Am Dent Assoc 1959; 59: 250-260.

6. Georgieva K, Abadjiev M, Kostadinov G, Gogushev K. Comparison of interfacial surface tension and capillarity of maxillary complete dentures fabricated by conventional cuvette

technique and injection molding technology. J of IMAB. 2016; 22(3): 1296-1300.

7. Nogueria SS, Ogle RE, Davis EL. Accuracy between compression and injection molded complete denture. J Prosthet Dent 1999; 82(3): 291-299.

8. Pryor WJ. Injection molding of plastic for dentures. J Am Dent Assoc 1942; 29: 1400-1408.

9. Grunewald AH, Paffenger GC, Dickson G. The effect of molding process on some properties of denture resins. J Am Dent Assoc 1952; 44: 269-284.

10. Mahler DB. Inarticulation of complete dentures processed by the compression molding technique. J Prosthet Dent 1951; 1(5): 551-559.

11. Pyeton FA, Anthony DH. Evaluation of dentures processed by differet techniques. J Prosthet Dent 1963; 13: 269-282.

12. Strohaver RA. Comparison of changes in vertical dimension between compression and injection molded complete dentures. J Prosthet Dent 1989; 62: 716-718.

13. Chintalacheruvu VK, Balraj RU, Putchala LS, Pachalla S. Evaluation of three different processing techniques in the fabrication of complete dentures. J Int Soc Prev Communit Dent 2017; 7 (7): 18-23.

14. Grant AA. Effect of investment procedure on tooth movement. J Prosthet Dent 1962; 12 (6): 1053-1058.

15. Salim, s., Sadamori, S., & Hamada, T. The dimensional accuracy of rectangular acrylic resin specimens cured by three denture base processing methods. J Prosthet Dent 1992; 67: 879-881.

16. Gharechahi J, Asadzadeh N, Shahabian F, Gharechahi M. Dimensional changes of acrylic resin denture bases:conventional versus injection-molding technique. J Dent, Tehran University of Medical Sciences. 2014; 11: 389-405.

17. Anderson GC, Schulte JK, Arnold TG. Dimensional stability of injection and conventional processing of denture base acrylic resin. J Prosthet Dent 1988; 60: 394-398.