Original article

An in-vitro study to evaluate the accuracy of dies obtained from dual arch impression trays using addition silicone impression material and tray combinations.

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Abstract

Background: Dual-arch impression technique allows the simultaneous recording of tooth preparation, opposing anatomic tooth and maxillomandibular relationship. The accuracy of reproduction of this easy and quick technique, however, has not been studied in detail in past. **Objective:** To compare the accuracy of the impressions made by using the same impression material in dual arch plastic trays, dual-arch metal trays and acrylic resin custom trays. **Methods:** The dies obtained from the addition silicone impressions made in dual-arch plastic trays, dual-arch metal trays and full arch acrylic resin custom trays were compared for the dimensional accuracy with the prepared typodont tooth as a control. Student's paired t-test and unpaired t-test were used for the data analyses using the Statistical Package for Social Studies (SPSS) version 11.5. **Results:** The dies obtained from all the impression combinations showed increased dimension (acrylic resin custom trays 9.4 mm±0.048, dual-arch plastic trays 9.5 mm±0.035, dual-arch metal trays 9.41 mm±0.017) as compared to the dimension of control (9.39 mm±0.007). **Conclusion:** All the tray-impression material combinations showed variable accuracies. Full arch acrylic resin trays resulted in greatest accuracy whereas dual-arch plastic trays the least accuracy.

Keywords: accuracy, addition silicone, custom tray, dual-arch tray

Introduction

Accurate impression is a crucial factor for the success of any prosthesis, hence impression materials and technique that exhibit good dimensional stability are required.[1] A variety of dental impression materials currently exist, the majority of which originated for use in non-dental-related fields.[2] Earlier, most of the impressions were made using either reversible or irreversible hydrocolloids.[3] These materials produced impressions with reasonable surface details, but had poor dimensional stability and low tear resistance while recording the gingival sulcus.[4] The need for a more stable, accurate, and elastic impression material introduced elastomers into dentistry.[1,5] Addition and condensation silicones became widespread in the market, but condensation silicone has less dimensional stability due to polymerization shrinkage. The addition silicones overcome the polymerization shrinkage as there is no by-product release.[6] However, addition silicones are expensive and may release hydrogen gas on setting, producing bubbles on die surfaces.[7,8] Polyether equals to addition silicone in dimensional stability, but being hydrophilic absorbs water or fluids. High rigidity, high modulus of elasticity, high cost, short working and setting times, and high stiffness after setting, limit their use.[7]

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Dual arch impression technique, developed by Wilson and Werrin[9], allows the simultaneous recording of tooth preparation(s), the opposing anatomical teeth, and the occlusal registration of the relative opposing dentition within a single impression tray for the fabrication of indirect restorations. Because three records are made simultaneously, it has also been referred as the 'triple tray technique'. They claimed that the dual-arch or double-arch impression technique is extremely accurate and a viable alternative to full-arch impressions.

Although the use of double-arch impressions has been widely accepted by private practicing dentists, the accuracy of the technique has not been verified by any reports other than the Davis and Schwartz series.[10-12] Most of the dual-arch impression trays offer minimal lateral support to the impression material, and the plastic trays are very flexible. Impression materials with high filler content and rigidity are often used to compensate for the poor support provided by the dual-arch tray; however, the higher viscosity impression materials may increase the distortion in a flexible tray. Even though the dual-arch impression technique has been claimed by Breeding and Dixon[13]to provide accurate and simple method for fabricating restoration using maxillo-mandibular relationship, its use should be limited to posterior single tooth preparations as suggested by Davis et al.[12]

The purpose of this study was to compare the accuracy of the impressions by using addition silicone elastomer in metal and plastic dual-arch impression trays.

Methods

This in-vitro study was conducted in the Department of Prosthodontics, Manipal College of Dental Sciences, Mangalore for comparative evaluation of dimensional accuracy of casts made by pouring of addition silicone impressions (Polyvinyl siloxane impression material, Heavy body & Light body, Reprosil, Dentsply/ Caulk, USA) using full arch acrylic custom tray, dual-arch metal tray (Quad tray Xtreme, Clinicians choice/ USA) and dual-arch plastic trays (Dual tray, Dispodent, Chennai, India) (Fig. 1). The ethical clearance was obtained from Institutional Ethical Committee, Kasturba Medical College, Mangalore.

The typodont teeth were embedded in the maxillary and mandibular Dentoform model bases (No. 500B-1, Kilgore Intl, Coldwater, Mich.) and the bases were mounted in maximum intercuspation on an articulator (Hanau H2, Teledyne WaterPik, Fort Collins, Colo.) to confirm the closed position of the guide pin on articulator incisal table (Fig. 2).

Figure 1: acrylic resin custom tray, dual arch plastic tray and dual arch metal tray

Figure 2: typodont teeth mounted in maximum intercuspation

The samples were divided into following four groups:

Figure 3: maxillary first molar prepared as the control.

Figure 4: stone dies obtained from dual-arch plastic tray impressions.

Figure 5: stone dies obtained from dual-arch metal tray impressions.

Figure 6: stone dies obtained from acrylic resin custom tray impressions.

Group A - Control (C) – consisted of the prepared molar typodont tooth embedded in the maxillary Dentoform model base (Fig. 3).

Group B - (PVS/PL) – consisted of dies obtained from the impressions made by using polyvinyl siloxane and plastic dual-arch trays (Fig. 4).

Group C - (PVS/M) – consisted of dies obtained from the impressions made by using polyvinyl siloxane and metal dual arch trays (Fig. 5)

Group D - (PVS/AC) – consisted of dies obtained from the impressions made by using polyvinyl siloxane and acrylic resin custom tray (Fig. 6).

Preparation of control

The typodont maxillary left first molar received complete crown preparation, with approximately 1.5 mm occlusal reduction on the functional cusps and 1 mm on the nonfunctional cusps. The functional cusp bevel was placed on the lingual inclines of maxillary lingual cusps as an integral part of the occlusal reduction using the round-end tapered diamond bur (856-016, Brasseler, USA). The buccal and lingual walls produced the desired axial reduction, forming a chamfer finish line approximately 0.75 mm in width placed just supragingivally using torpedo diamond point (877 -010, Brasseler, USA).

After crown preparation with straight fissure bur (256; Brasseler, USA), tooth was removed from the dentoform, notches were placed in the margin buccally and lingually using the tapered fissure bur (170L-010 Brasseler, USA) and the sharp corners of the notches were used as reference points. The digital caliper (Digimatic 500-321; MTI Corp, Aurora) was used to measure the buccolingual width of the tooth at the margin by using the sharp corners of the notches as reference points. The buccolingual dimensions of the preparation were recorded for comparison to the subsequent dies, and the preparations were reaffixed in the dentoform.

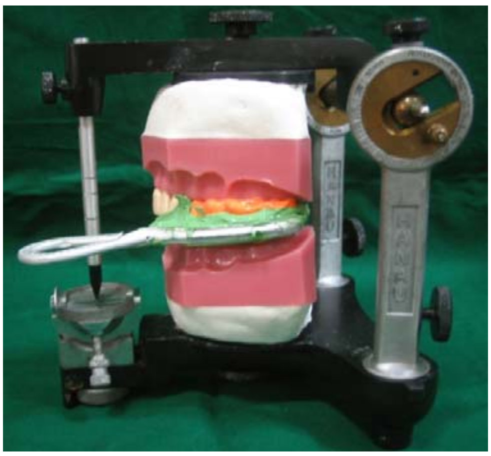

Figure 7: position of dual-arch metal tray during impression making.

Impression making

Impressions were made with addition silicone impression material by using multiple mix-single step technique. The impressions were also grouped as following:

Group A impressions

Sectional plastic dual-arch trays were used to make the impressions using one step technique. The trays were assessed to ensure that the typodont could be closed into the maximum intercuspation position without any interference from the tray. Tray adhesive was not used for plastic dual-arch trays. Impression material was syringed around the prepared tooth and loaded on the tray. The articulator was closed and the impression was allowed to set for twice the manufacturer's recommended setting time to compensate for the temperature of the extra-oral environment. A total of eight impressions were made that were rinsed under tap water for 10 seconds and dried.

Group B impressions

Sectional metal dual-arch trays were used to make impressions using a one-step technique. The procedure was similar to that performed in group A impressions except that the tray adhesive (Caulk Tray Adhesive, Dentsply/Caulk, USA) was applied on the walls of metal dual-arch trays. A total of eight impressions were made in this group too.

Group C impressions

Impressions were made using the acrylic resin custom trays that were prepared by placing uniform thickness of 2 mm of wax spacer. The fit of the trays were confirmed. The tray adhesive was painted on the walls and borders of the trays and was allowed to dry for five minutes. Light bodied material was mixed and loaded in a syringe that was injected around and over the prepared tooth. Heavy-bodied material was loaded in the custom tray and the tray was positioned over the maxillary arch. After ten minutes of setting time from the start of mix, the impression was removed by applying equal pressure bilaterally and the impression was evaluated, rinsed under tap water and air dried. A total of eight impressions were made in this group too.

All the impressions above were poured with type IV dental stone (Kalrock, Kalabhai Karson, Mumbai, India) following manufacturer's specified water/powder ratio. The opposing arch was not poured in the dual-arch impressions. The stone dies were retrieved from the impressions after setting time of 2 hours.

The dimensions of the original preparation were compared with the dimensions of the dies measuring with digital caliper (Digimatic 500-321; MTI Corp, Aurora).

The data were statistically analyzed using software SPSS (Statistical Package for Social Sciences) version 11.5. Student's paired't' test and unpaired't' test were used. A value of $p < 0.05$ was considered to be statistically significant.

Results

The results obtained from this study are shown in tables 1 and 2 and graph 1.

Table 1: Mean buccolingual dimensions of control and dies

Particulars	Number	Mean Buccolingual dimensions (mm)	Standard deviation (mm)
Control	10	9.39	0.007
Acrylic custom tray	8	9.40	0.048
Dual arch plastic tray	8	9.51	0.034
Dual arch metal tray	8	9.407	0.017

Graph 1: Inter-group comparison of mean buccolingual width

Table 1 and graph 1 show the mean buccolingual dimensions of prepared typodont tooth (as control) and the buccolingual dimensions of the dies obtained from the impressions made using full arch acrylic custom trays, dual – arch plastic trays and dual – arch metal trays.

Table 2: Difference of means of buccolingual dimensions of control and different dies

Mean Buccolingual dimensions of		Difference of means (mm)	P value
Control	Acrylic custom tray	0.01	0.89
	Dual arch plastic tray	0.12	0.001
	Dual arch metal tray	0.017	0.65
Acrylic custom tray	Dual arch plastic tray	0.11	0.001
	Dual arch metal tray	0.007	0.97
Dual arch plastic tray	Dual arch metal tray	0.103	0.001

Table 2 shows the intergroup comparisons among the dimensions of control and the dies obtained with various impression– tray combinations. Statistically significant difference was seen between the dimensions of control and the dies produced using dual arch plastic trays. Similarly the difference in the dimensions of dies produced by using full arch acrylic custom tray and dual arch plastic tray as well as the difference in the dimensions of dies produced by using dual arch metal trays and dual arch plastic trays were found to be statistically significant ($p < 0.001$). In summary, all the dies produced from various tray-impression combinations showed increase in buccolingual dimensions as compared to control. Plastic trays produced the largest dies whereas the dies produced by using impressions in full arch acrylic custom trays had the closest dimensions to the control.

Discussion

Custom trays improve the accuracy of an elastomeric impression by limiting the volume of the material, thus reducing stresses during removal and polymerization contraction increasing accuracy. Autopolymerizing acrylic resin, thermoplastic resin as well as photo polymerized resins are used. The custom trays should be rigid, dimensionally stable and at the same time easy to fabricate. The advantages of custom trays include less material required, no need of sterilization and relatively small amount of distortion. However, the time consumed for fabrication and the need to store them for at least 24 hours to minimize the distortion of autopolymerized resin are the disadvantages.

Dual arch trays, also known as quad trays or triple trays are made of metal or plastic with or without side walls. Metal trays are rigid and will not deform during the impression procedure. Plastic dual-arch trays are flexible to varying degrees, depending on the shape and dimensions of the side wall.

The dual- or double- arch impression technique as described by Wilson and Werrin[9] is convenient in that it makes the maxillary and mandibular impressions, as well as the interocclusal record in one procedure. The dual arch impression technique allows the impression to be made in closed mouth position. This position provides two benefits: (1) the mandibular flexure that occurs after 28% of maximum opening is eliminated, and (2) teeth are placed near maximum intercuspation.

Although distortion of an impression is a 3-dimensional problem that is inherent in all of the steps involved in fabricating an indirect dental restoration, the buccolingual dimension of the gingival margin was chosen because this is one of the least supported areas of impression in most of the dual- arch impression trays. Any flexure or rebound of the impression in the buccolingual direction would result in a corresponding error in the mesiodistal direction; however, this dimension was not measured in this study.

The result of present study showed increased buccolingual dimension in all the series of dies prepared (9.4 mm, SD- 0.048 in case of acrylic custom tray, 9.5 mm, SD- 0.035 in case of dual arch plastic tray and 9.407 mm, SD- 0.017 in case of dual arch metal tray as compared to the 9.39 mm, SD 0.007 of control). The altered dimensions might be attributed to the polymerization shrinkage in the polyvinyl siloxane impression material. This material shrinks towards the centre of mass during polymerization. The use of tray adhesive would redirect this shrinkage towards the wall of the tray, resulting in an increase in the buccolingual dimension. Hence, these findings of the study are in agreement with the results obtained by Breeding and Dixon[13] and Ceyhan et al.[14] in that the buccolingual dimensions increased and mesiodistal dimensions decreased.

The difference in the mean buccolingual dimensions of control as well as the dies obtained from various impressions revealed that the increased dimension of dies from dual-arch plastic trays were statistically significant value as compared to all other three types. The findings were in agreement with the work done by Breeding and Dixon[13], Ceyhan et al.[14], Cox JR, Brandt RL and Hughes HJ[15]. This variation in dimension can be attributed to the relative flexibility of the plastic dual-arch trays in comparison to the metal dual arch trays and the full arch acrylic custom tray. The more flexible plastic trays provided less rigid support at the borders and these were flexed outward by the impression material during seating on the prepared tooth. Another possible explanation for the increased dimension seen with the plastic dual arch trays may be distortion caused by the weight of the stone when the impression was poured. Only the side of the tray with the prepared tooth was poured in this study. The metal tray and acrylic custom tray would resist any flexure due to the weight of the stone, but the flexible plastic tray may distort.

However, the study conducted by Larson TD et al[16] revealed that the flexed dual arch impression trays produced significantly undersized dies compared to the custom trays and to passively seated dual- arch trays, which is not in agreement with the findings of the present study. Since that study measured the mesiodistal dimension which was not measured in the present study and hence it cannot be merely compared for any conclusion.

Measurements made on the stone casts are potentially affected not only by the impression materials and tray type, but also by the expansion of dental stone used. In this study, improved die stone with a reported low-expansion of 0.10% was used.

Statistical analysis which showed a significant difference ($p < 0.001$) between the measurements recorded at different points on the preparation margins may possibly relate to the pattern of distortion in the impression of the preparation, and particularly when the distorted tray relaxes upon removal of the impression. The results that showed the dies obtained from plastic dual-arch tray impressions with least accurate buccolingual dimension supported the theory that ‘it is advantageous to use a more rigid tray to make an accurate impression’.

Limitations of the study

Few of the limitations of this study were those the change in dimension was measured only in one direction i.e. buccolingual and not the mesiodistal. The possibility of change in dimension of the control and dies produced by these various impression/trays combinations might be different in other direction than buccolingual. Hence the change in dimensions in mesiodistal direction also should be considered while studying for the accuracy of impression techniques. Impressions were poured only on the side of interest i.e. on the side of prepared tooth and the opposite side of the impression was left free. Due to the load of die stone poured, the impression may flex in various amounts in such cases if the other side is not poured and this flexing of the impressions may be more in case of flexible tray materials like plastic dual-arch trays.

Conclusion

Within these limitations this study concluded that the full arch acrylic custom trays produced the most accurate dies as compared with those produced by using metal or plastic dual-arch trays; acrylic custom trays and metal dual-arch trays produced more accurate dies as compared to those produced by plastic dual-arch trays; impressions made with rigid tray had acceptable die dimensions and the flexure of plastic dual-arch tray during impression making appeared to adversely affect the accuracy of dies.

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