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Original Research

In vivo Study of the Accuracy of Dual-arch Impressions

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Abstract:

Background: This study evaluated *in vivo* the accuracy of metal (Smart®) and plastic (Triple Tray®) dual-arch trays used with vinyl polysiloxane (Flexitime®), in the putty/wash viscosity, as well as polyether (Impregum Soft®) in the regular viscosity.

Materials and Methods: In one patient, an implant-level transfer was screwed on an implant in the mandibular right first molar, serving as a pattern. Ten impressions were made with each tray and impression material. The impressions were poured with Type IV gypsum. The width and height of the pattern and casts were measured in a profile projector (Nikon). The results were submitted to Student's *t*-test for one sample ($\alpha = 0.05$).

Results: For the width distance, the plastic dual-arch trays with vinyl polysiloxane (4.513 mm) and with polyether (4.531 mm) were statistically wider than the pattern (4.489 mm). The metal dual-arch tray with vinyl polysiloxane (4.504 mm) and with polyether (4.500 mm) did not differ statistically from the pattern. For the height distance, only the metal dual-arch tray with polyether (2.253 mm) differed statistically from the pattern (2.310 mm).

Conclusion: The metal dual-arch tray with vinyl polysiloxane, in the putty/wash viscosities, reproduced casts with less distortion in comparison with the same technique with the plastic dual-arch tray. The plastic or metal dual-arch trays with polyether reproduced cast with greater distortion.

Key Words: Impression material, polyether, tray, vinyl polysiloxane

Introduction

Indirect restorations are widely used in dentistry. For the restoration to fit correctly, special attention is required in the impression procedure, for which there are several techniques, using various types of trays and materials.

Among the different elastomeric impression materials, vinyl polysiloxane and polyether are widely accepted due to their reproduction capacity[1,2] and dimensional stability.[3,4] Different impression techniques can be used with these materials, such as the one- and two-step technique,[5-7] as well as materials with different viscosities.[8,9] Irrespective of the technique used, it is always necessary to use a tray.

Plastic and metal dual-arch trays have been used for over two decades for inlays, onlays, overlays, complete crowns, and veneers. This technique has gained wide popularity due to the advantages, such as time savings, for dentists and patients, patient comfort and savings on impression materials.[10,11] This technique is known as the dual-arch impression technique, double-arch technique or triple-tray technique, and it was first described by Wilson and Werrin.[12] It is a closed-mouth impression technique, which uses a special tray to register an impression of opposing segments of the dentition, while simultaneously recording the occlusal relation of these opposing segments. The patient closes into a tray in which a thin piece of mesh divides the tray into maxillary and mandibular compartments. Once taken, the impression is poured and mounted in an articulator.

The majority of studies assessing trays are conducted *in vitro*. One study has shown that the metal dual-arch tray is more accurate in comparison with the plastic tray,[13] while another has shown evidence that both dual-arch trays are as accurate as the custom tray.[14] However, *in vitro* studies are unable to reproduce the same oral cavity conditions as those of *in vivo* studies.

Few *in vivo* researches assessing dual-arch trays have been conducted. Cox *et al.*[8] conducted a clinical pilot study in which vinyl polysiloxane impressions were made of cast metal copings cemented onto natural teeth prepared as full crown abutments. They found greater distortion when the plastic dual-arch tray was associated with heavy- and low-viscosity vinyl polysiloxane. Ceyhan *et al.*[15] conducted a clinical study with eight patients with single implants in the molar or premolar region, and found that the plastic dual-arch tray produced less distortion; however, both the plastic and metal trays produced casts with acceptable dimensions for clinical success. Cox[16] evaluated the occlusion and marginal fit of posterior full crowns made from dual-arch impressions, and compared these with control crowns fabricated from conventional complete-arch impressions. They concluded that crowns fabricated from the dual-arch impressions were equivalent in marginal accuracy

to crowns fabricated from complete-arch impressions. In the study of Johnson *et al.*,[17] there was little difference in success rates between vinyl polysiloxane and polyether when full-arch impression trays were used, but there was greater success when using vinyl polysiloxane with dual-arch trays. For single teeth, the trend favored vinyl polysiloxane, but when more than one prepared tooth per impression was involved, the success rate was higher for polyether.

In view of the controversies in the literature, the aim of this study was to compare *in vivo*, the accuracy of plastic and metal dual-arch trays with two impression materials. This study was conducted under the hypothesis that metal and plastic dual-arch trays present no difference in accuracy when used with vinyl polysiloxane or polyether.

Materials and Methods

A 21-year-old female patient was selected at the prosthodontics clinic of the Dental School at Pontifical Catholic University of Rio Grande do Sul (PUCRS). The patient required implant placement in the region of the right mandibular first molar and she had natural teeth in both arches and normal occlusion. The experimental procedures were undertaken with the understanding and written consent of the patient, following protocols reviewed and approved by the Research Ethics Committee of the PUCRS.

An external hexagon implant (3i®, São Paulo, SP, Brazil) with the following dimensions was placed: 10 mm high × 3.75 mm in diameter, with platform 4.1 mm in diameter. The impressions were made 4 months after implant placement. An implant-level transfer, code 025020 (Conexão®, São Paulo, SP, Brazil), was cut through its cylindrical part, and served as the pattern. The three lines on the transfer served as height measurement reference points, and one of the sides was flattened with a carborundum disk and polished to metal using rubber (Figure 1). At the time of the impressions, the pattern was screwed to the implant, so that the flattened region was at all times positioned on the buccal face (Figure 2). Ten impressions were made for each experimental group, and each impression sequence was done on different days because of possible soft-tissue trauma from the impression-making procedures, and also to avoid tiring the patient.

Before the impression, the patient was informed about the procedure used, and trained with regard to the way she should occlude her teeth at the moment of impression. The trays were tested to certify that they were of the correct size for the clinical case.

Group 1: Metal dual-arch tray with vinyl polyxiloxane-the base and catalyst putty material (Flexitime®, Heareus-Kulzer, GmnH and Co. KG, Germany) were dispensed and mixed by an operator until a homogeneous mass was obtained, and both sides of the metal dual-arch tray (Smart®, SS White, São Paulo,

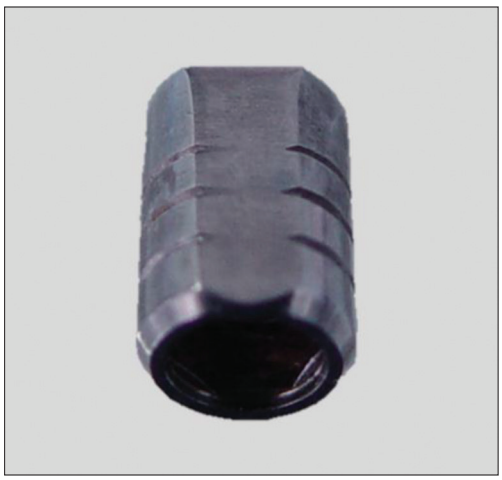

Figure 1: Implant-level transfer cut through its cylindrical part. The three lines on the transfer served as height measurement reference points, and one of the sides was flattened.

Figure 2: The flattened region of the transfer positioned on the buccal face.

SP, Brazil) were filled with this material. Simultaneously, a second operator applied the wash material around and over the pattern, using the syringe supplied by the manufacturer. Next, the operator seated the tray on the pattern, and the patient was instructed to close until her contralateral teeth were in the rehearsed maximum intercuspal position. After 5 min, the operator removed the impression.

Group 2: Metal dual-arch tray with polyether - an adhesive for polyether was applied (3 m/espe, Seefeld, Germany) on the tray. Equal lengths of medium-consistency base and catalyst pastes (Impregum Soft®, 3M/espe, Seefeld, Germany) were dispensed on an impermeable paper and mixed with a spatula for 45 s. The material was placed on both sides of the tray, and simultaneously, a second operator applied the material around and over the pattern using a syringe. Next, the operator seated the tray on the pattern, and the patient occluded her dental arches. After 5 min, the operator removed the impression.

Group 3: Plastic dual-arch tray with vinyl polysiloxane - the procedure was the same as that described for Group 1, but now the plastic dual-arch tray (Triple Tray®, dfl, Jacarepagua, RJ, Brazil) was used.

Group 4: Plastic dual-arch tray with polyether - the procedure was the same as that described for Group 2, but now the plastic dual-arch tray was used.

All the impressions were made by the same operators, at a temperature of 23 ± 1°C. Soon after the impressions were removed from the oral cavity, they were rinsed under tap water for 30 s. The impressions were disinfected by spraying them with 2% glutaraldehyde and kept in a closed plastic bag for 10 min. They were then rinsed in tap water for 30 s, dried, and poured in gypsum 60 min later. Fifty grams of Type IV gypsum (Durone®, Dentsply, Petrópolis, RJ, Brazil) was hand mixed with 9 mL of water for 1 min and vibrated into impressions. First, the side corresponding to the pattern was poured. After initial setting, the other side was poured with Type III gypsum (16 mL/50 g). After 1 h, the casts were removed and stored in a dry environment. The region corresponding to the replica of the pattern was individualized from the cast.

The width (mesio-distal distance) and height (distance between the superior and inferior line) of the pattern and the cast were measured (Figure 3), using a profile projector model V16 (Nikon®, Tokyo, Japan) with a measurement sensitivity of 0.001 mm. The flattened region of the pattern and the casts were seated on the equipment platform, and three measurements were made in each direction, and a mean was obtained. A single examiner obtained the measurements.

The width and height of the pattern was measured 10 times, at two different times to assess intra-examiner reproducibility. According to Student's *t*-test for paired samples ($\alpha = 0.05$), there was no statistically significant difference for both the width ($P = 0.274$) and height ($P = 0.784$) measurements, indicating examiner's calibration.

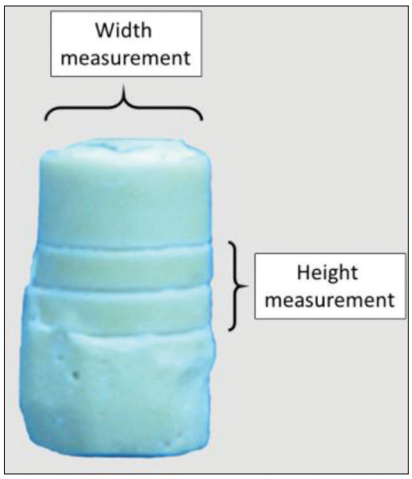

Figure 3: Measurement of the width.

For comparison of the experimental groups with the pattern, the student's *t*-test for one sample was used ($\alpha = 0.05$). The statistical analyses were performed using SPSS version 10.0 (SPSS Inc., Chicago, IL, USA).

Results

According to Student's *t*-test for one sample ($\alpha = 0.05$) the width means of the plastic dual-arch tray with vinyl polysiloxane (4.513 mm) and the plastic dual-arch tray with polyether (4.531 mm) were statistically higher than those of the pattern (4.489 mm). However, the metal dual-arch tray with vinyl polysiloxane (4.504 mm) and the metal dual-arch tray with polyether (4.500 mm) presented no statistically significant differences in the width means in comparison with the pattern (4.489 mm) (Table 1).

Only the metal dual-arch tray with polyether (2.253 mm) presented a height mean statistically lower than that of the pattern (2.310 mm). For the other groups, the height means did not differ statistically from the pattern, the casts being shorter for the plastic dual-arch tray with polyether (2.293 mm) and metal dual-arch tray with vinyl polysiloxane (2.299 mm), and higher for the plastic dual-arch tray with vinyl polysiloxane (2.351 mm) (Table 2).

Discussion

The impression procedure is a fundamental stage of indirect restorations, as the lack of accuracy due to distortions may significantly compromise the fit of restorations and their longevity.

The majority of studies comparing trays are conducted *in vitro*, using stainless steel models[3,7,18,19] or typodonts.[9,13,14,20-22]

Table 1: Comparison of the width means of the experimental groups.

Group	*n*	Mean (mm)	Pattern (mm)	SD	Difference (µm)	*P*
PT+VP	10	4.513	4.489	0.015	+24	0.001
PT+P	10	4.531	4.489	0.028	+42	0.001
MT+VP	10	4.504	4.489	0.023	+15	0.069
MT+P	10	4.500	4.489	0.011	+11	0.061

PT: Plastic dual-arch tray, MT: Metal dual-arch tray, VP: Vinyl polysiloxane, P: Polyeter, SD: Standard deviation

Table 2: Comparison of the height means of the experimental groups.

Group	*n*	Mean (mm)	Pattern (mm)	SD	Difference (µm)	*P*
PT+VP	10	2.351	2.310	0.113	+41	0.281
PT+P	10	2.293	2.310	0.032	−17	0.134
MT+VP	10	2.299	2.310	0.037	−11	0.211
MT+P	10	2.253	2.310	0.054	−57	0.009

PT: Plastic dual-arch tray, MT: Metal dual-arch tray, VP: Vinyl polyxiloxane, P: Polyeters

However, these studies do not faithfully reproduce the texture of the teeth and gingiva, bite force, humidity and temperature in the oral cavity. For this reason, the present study was conducted *in vivo* in order to reproduce the clinical situation.

An implant-level transfer was selected as pattern, which allowed it to be measured extra-orally and positioned on the implant in a standardized way for the impression procedures. One of the sides of the transfer was flattened, and this flattened area was always located on the buccal face. This flattened surface also allowed the position of the casts in the profile projector to be standardized.

The initial hypothesis of this study was rejected. For the width measurements, the metal dual-arch tray produced the least distortions, providing casts 15 μm wider with the vinyl polysiloxane, and 11 μm wider with polyether. The plastic trays produced greater distortion, the casts being 24 μm wider when vinyl polysiloxane was used and 42 μm wider with the polyether. Probably this occurred because the plastic tray is less rigid, favoring less support at the edges and a certain flexibility at the time of its removal, and consequently, greater distortions. Breeding and Dixon,[13] Larson *et al.*[23] compared metal and plastic dual arch-trays *in vitro*, and also found that the metal trays provided less distortion in comparison with the plastic trays. Whereas other studies did not specifically study the dual-arch trays, but found that plastic trays for complete impression of the dental arch also favored the greatest distortions *in vitro*.[18,24-26]

The casts obtained from the plastic dual-arch trays were larger than those obtained from the metal trays. According to Breeding and Dixon,[13] a possible explanation for this would be the possibility of the weight of the gypsum causing greater distortion in the plastic tray at the time of pouring the tray, as the metal tray was more resistant to the deformation caused by the weight of the gypsum.

Although the statistical analysis demonstrated statistically significant difference between the width mean of the pattern and the casts obtained from the plastic trays, it is important to question whether this difference is clinically relevant. It is difficult to estimate exactly what magnitude of distortion could influence the fit of the restoration, but according to Idris *et al.*,[6] differences of up to 32 μm are not clinically relevant. Therefore, the plastic tray with polyether would be the only impression that could prejudice the fit, since the cast was 42 μm wider than the pattern.

Vinyl polysiloxane and polyether are elastomeric materials that have reproduction capacity[2] and dimensional stability.[3,4] Studies have shown that the two materials presented clinically acceptable results.[1] In the present study, the vinyl polysiloxane Flexitime was used with putty and wash viscosities, and impregnum polyether with medium viscosity, characterizing a single phase material.

In the impression procedure, the material must resist the forces that are generated during its removal from the oral cavity, and could deform permanently when removed from retentive areas. Therefore, elastic recovery is an important property for determining the accuracy of an impression material. Lu *et al.*[27] studied the elastic recovery of the Flexitime and Impregum, and found that polyether was the material that presented the least elastic recovery. This finding is in agreement with the greater distortion obtained with the plastic tray when using polyether (42 μm), in comparison with the plastic tray used with vinyl polysiloxane (24 μm). Possibly, the lower rigidity of the plastic tray produced greater deformation of the polyether at the time of its removal from the oral cavity, causing greater distortion due to the lower elastic recovery of the material. Greater distortions were also found for polyether in comparison with vinyl polyxiloxane.[28,29]

When comparing the casts obtained with the two impression materials, it was visually observed that the lines on the pattern, which served for the height measurements, were clearer in the casts obtained from the vinyl polysiloxane. Probably the wash viscosity of the vinyl polysiloxane had a greater capacity to reproduce these lines, in comparison with the mean viscosity of the polyether.

In the height measurement, the polyether produced greater distortion, and this result may be also related to the adhesive. The purpose of the adhesive applied to the tray is to bond it to the impression material to prevent it from being displaced. In the present study, the adhesive was applied only to the polyether, and although it had not been applied to the vinyl polysiloxane, clinically no loss of union between the material and both metal and plastic trays was observed. According Ceyhan *et al.*,[9] the application of the adhesive produces contraction of the material in the direction of the tray walls, which can result in shorter casts. The casts were shorter with the metal tray (57 μm) in comparison with the plastic tray (17 μm). Probably it is due to the rigidity of the metal tray, which does not absorb the stress contraction of the impression material, allowing higher deformation. This distortion of 57 μm would be clinically relevant and could be minimized by the use of a spacer to increase the dimension of the cast.[30] The metal tray with vinyl polysiloxane also reproduced shorter cast (11 μm). Without the adhesive application, the impression material contracts in the direction towards the center of the mass, favoring obtainment of smaller models.[9] Another explanation for the shorter casts is that the putty material may exhibit some elastic recovery upon removal of the impression, resulting in a tendency toward smaller casts.[6] Probably, there is no clinical relevance for the shorter casts obtained with the plastic tray with polyether (17 μm) and the metal tray with vinyl polysiloxane (11 μm).

Only the plastic tray with vinyl polysiloxane reproduced casts that were dimensionally longer than the pattern (41 μm). This value might be related to the less rigidity of the plastic tray, allowing higher deformation of the material at the time of its removal from the oral cavity. Probably the difference of 41 μm does not have clinical relevance, since a model that is slightly larger than the preparation is clinically desirable, due to the space necessary for the cementation material.[18]

Elastomeric material distortion is undesirable, and various factors may contribute to it, such as disinfection of the impressions.[31] This procedure is important for preventing cross contamination. Therefore, in the present study, the impression was rinsed under tap water for 30 s immediately after it was removed, followed by disinfection with 2% glutaraldehyde for 10 min. Studies have shown that when this procedure was performed for a period of 10 min, it did not significantly alter the dimensional stability of the elastomeric impression material.[32,33]

The present study has some shortcomings: (a) the finishing line was not evaluated, which is a major concern specifically in crowns; (b) all impressions were taken in one patient, which is a limitation to the real clinical situation. Independent of these limitations, the results showed evidence that distortions did occur, irrespective of the type of association between the tray and impression material. Furthermore, inadequate fit of a restoration may be the sum of small distortions that occur during the procedures in the clinical and laboratory steps, and not exclusively due to the impression and/or the material. There seems to be consensus that a smaller distortion is necessary for obtaining good fit. As the tray/impression material association plays an important role in this subject, it would be interesting to study the association between dual-arch trays and other material viscosities, such as heavy/wash technique.

Conclusion

Within the limitations of this study, it was possible to conclude that the metal dual-arch tray with vinyl polysiloxane, in the putty/wash viscosities, reproduced casts with less distortion in comparison with the same technique with the plastic dual-arch tray. The plastic or metal dual-arch trays with polyether reproduced cast with greater distortion.

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