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Evaluation of Splinting Implant Impression Techniques: Two Dimensional Analyses

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Abstract - *This paper aims to evaluate the effect of splinting during implant impression. A master model with two fixtures at the sites of 45 and 47 was used. 20 impressions were made for all four techniques: (A) indirect; (B) direct, unsplinted; (C) direct, splinted; and (D) direct, splinted, sectioned, and re-splinted. Splinting was undertaken with autopolymerizing acrylic resin (AAR). Horizontal distance between fixtures was compared using a digital caliper. The difference in distance were analysed with one-way ANOVA. Group A showed a significantly lowest accuracy among all techniques ($p \leq 0.05$). There was no significant difference of accuracy among the groups using direct techniques ($p \geq 0.05$). Group D was more accurate compared to group B and C. We conclude that splinting of impression copings would be beneficial to obtain an accurate impression.*

KEYWORDS: multiple implants impression techniques, horizontal distance, splinting techniques

INTRODUCTION

Multiple implant impressions required extreme accuracy for the relationship among fixtures to be transferred precisely to the working cast. Small errors could lead to misfit of the superstructure and therefore transfer stress to the surrounding bone as there are no periodontal ligaments to cushion it[1]. The accumulation of preloaded and loading stresses in the restoration complex could cause problems ranging from screw loosening to loss of osseointegration[2-3].

To date, various impression techniques have been introduced and tested for accuracy[4-14], however, the results are controversial. Indirect, direct, splinting and re-splinting techniques are among techniques advocated for multiple implant impressions. Indirect impression techniques were found to produce a greater mean distortion than the direct techniques[4,9-12]but presents a more simple clinical procedure. Distortion might happen during the reinsertion of the impression copings into the impression before casting. However, a study conducted by Humphries *et al.* achieved higher accuracy with indirect technique if tapered coping and closed tray were used[8]. Moreover the study stated that the torque necessary to fasten square copings on analogs in the direct technique may create more distortion than the inaccuracy resulted from the replacement of copings.

Lee *et al.* reviewed studies on implant impressions and concluded that splinted technique has been reported to be more accurate compared to non-splinted technique[15]. However, possible problems with the splinting material such as fractures or distortion has been encounted. The bulk shrinkage caused by a long splinting might also cause considerable distortion hence, re-splinting technique would give an accurate transfers while avoiding unnecessary distortion by the material bulk shrinkage or fractures. Autopolymerizing acrylic resin (AAR) has been reported to be the material of choice for splinting, as it would give more accurate location of the impression copings, compared to dual-cure acrylic resin and impression plaster[9,12,16].

Naconecy *et al.* have conducted study to evaluate the accuracy of three impression techniques; indirect, splinted and non-splinted[7]. The study concluded that splinted technique was the most accurate transfer method for multiple abutments compared to direct non-splinted and indirect techniques. The direct non-splinted and indirect techniques resulted in similar transfer deformation[7]. Humphries *et al.*, Hsu *et al.* and Herbst *et al.* found no significant differences between the values obtained with splinted versus non-splinted copings in an impression techniques[8,12-13]. By contrast, Assif *et al.* indicated that splinting is more accurate than the non-splinted technique[16].

The aim of this study was to evaluate the effect of splinting two impression copings during impression making by measuring the horizontal differences between master model and resultant cast. Furthermore, the horizontal differences of direct and indirect impression techniques were compared.

The hypothesis of this study is resultant casts obtained from impression of indirect technique would present with less accuracy compared with other techniques. Furthermore, splinting of the impression copings would be more accurate.

MATERIALS AND METHODS

A mandibular dental study model with two parallel fixtures (45 and 47) was used as master model (Figure 1). Distance

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between two impression copings on the master model was measured using digital caliper before impression making (Figure 2). Three repeated readings were obtained by a single examiner. Customized closed and open impression trays were fabricated using light cured acrylic resin.

Four impression techniques were conducted for the study using medium viscosity of polyether impression material. Table 1 shows the impression techniques that were conducted. Twenty impressions were made for each technique using the particular impression copings. In group A, transfer copings were used for the indirect impression, with a closed custom tray, while in group B, C and D, pick-up impression copings were used with an open custom tray. Impression copings in group C and D were connected with dental floss and autopolymerizing acrylic resin (AAR) was then mixed according to the manufacturer's instruction and covered the dental floss. The bulk of acrylic splint in group D was sectioned with sectional disc into two fragments after it's initially set. Another mix of AAR was reapplied at the sectioned area and was left to set. Acrylic splint in group C was left unsectioned. Impression copings in group A and B were left unsplinted. Figure 3 showed the impression copings before impression making.

All impressions were left to set on the master model for 5 minutes to ensure the impression material was fully polymerized. After removal of the impression, laboratory analogs were fitted into the copings in the impression body and were secured with the guide pins for group B, C and D. While in group A, transfer copings were removed from the master model and screwed to the lab analogs. The assembly was then fitted into the impression body.

All impressions were washed under running water for 1 minute and disinfected with disinfectant for 10 minutes, following with 1 minute of washing under running water. All impressions were dried and stored below 30ºC in the dark for 2 hours before casted with ADA type IV dental stone. The dental stone was spatulated in a vacuum mechanical mixer for 30 seconds and casted under constant vibration. After an hour, the impressions were separated from the cast. All casts were then further left for a day in an open air environment to make sure they were fully dried up. The casts were then trimmed accordingly. Figure 4 showed one of the resultant cast before insertion of copings.

The same pair of squared copings was used on all resultant casts for measurement purposes. The measurements were taken at 2 reference points as on the master model, using

Figure 1. *Master model with two fixture, 45 and 47*

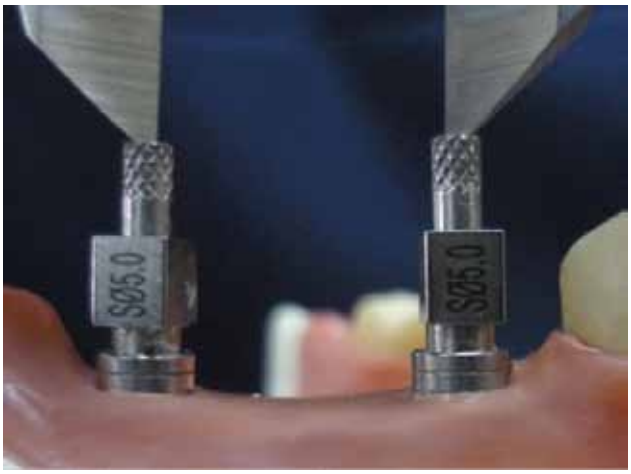

Figure 2. *Distance between pick-up impression copings on master model using digital caliper*

Table 1. *Impression techniques*

GROUP	*DESCRIPTION*	*CUSTOM TRAY*	*IMPRESSION COPING*
A	Indirect Impression copings unsplinted	Closed tray	Transfer
B	Direct unsplinted Impression copings unsplinted	Open tray	Pick-up
C	Direct splinted Impression copings splinted with dental floss and AAR, unsectioned	Open tray	Pick-up
D	Direct splinted, sectioned, resplinted Impression copings splinted with dental floss and AAR, sectioned and resplinted with AAR	Open tray	Pick-up

AAR = autopolymerizing acrylic resin

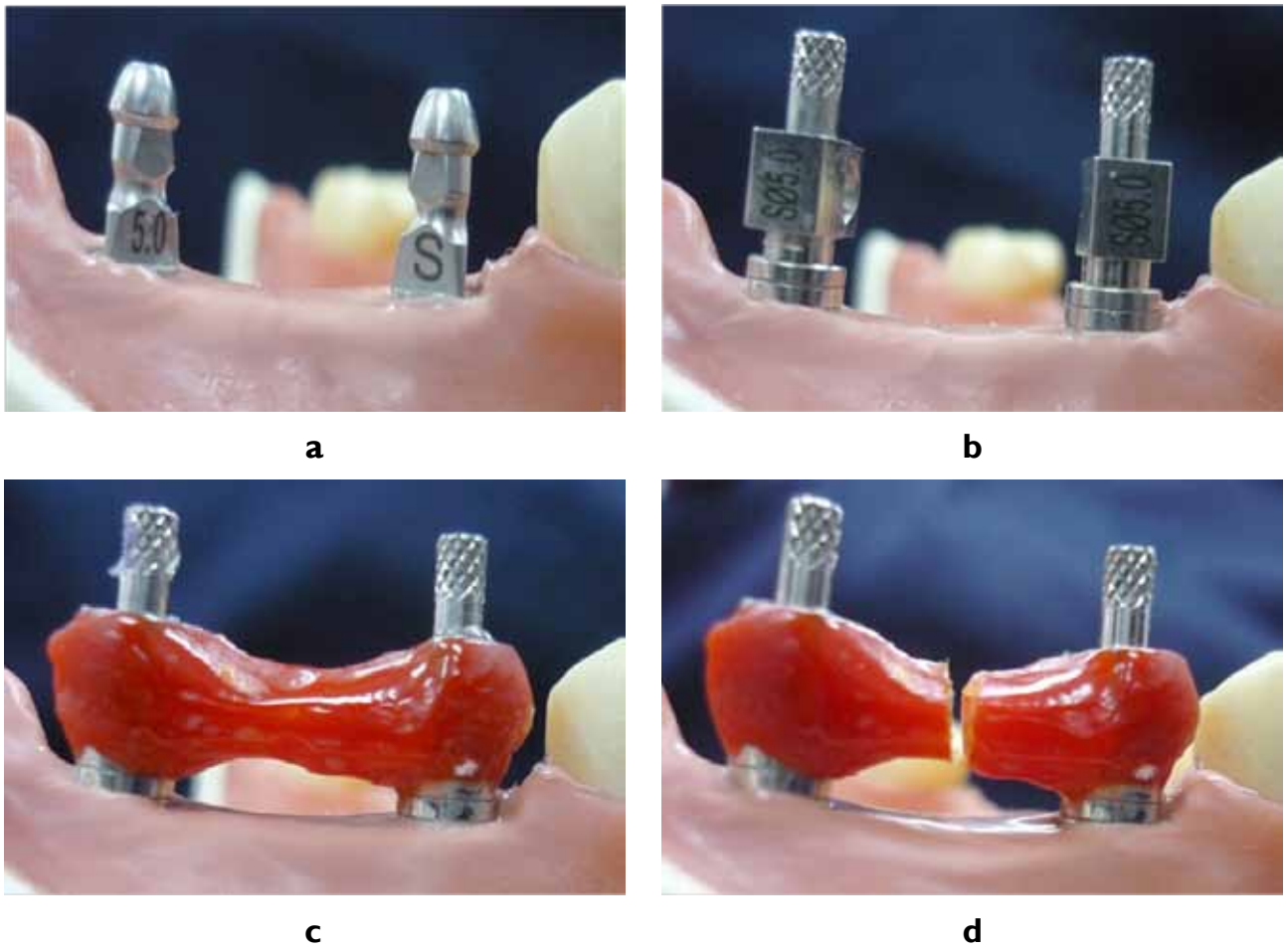

Figure 3.
(a) Transfer copings for group A; (b) Pick-up copings for group B; (c) Pick-up copings for group C, splinted with dental floss and AAR; (d) Pick-up copings for group D, before resplinted with AAR

Figure 4. *Resultant cast*

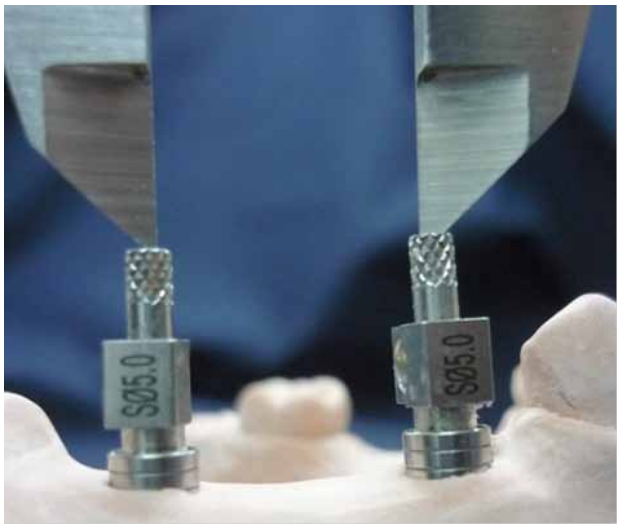

Figure 5. *Distance between two impression copings was taken at the same reference point on the pick-up impression copings*

digital caliper by single examiner (Figure 5). The distance between 2 reference points on the resultant casts were compared to those on the master model. The mean from three repetitive readings and the difference in distance were recorded for each resultant cast. Mean variation from each group was calculated and compared for accuracy. The data were further analyzed with one-way ANOVA following Tukey's Test for multiple comparison, where the mean difference was set to be significant when $p \leq 0.05$. Data obtained from the resultant cast were compared with the master model.

RESULTS

The distance between copings obtained from the master model was 13.017mm. The mean of differences in distance from different groups were presented in Figure 6. Each group consists of 20 samples and the variations were calculated in micrometer (µm). The mean changes in distance was +67.90µm (SD ±34.7) group A casts, +30.25µm (SD ±22.1) group B casts, +33.20 µm (SD ±23.9) group C casts and +21.75µm (SD ±14.9) group D casts. A total of 69 (86.25%) resultant cast were found to show an increased in the horizontal dimension. Table 2 shows the distribution of horizontal movements (changes in distance) for each group.

Changes in distance for all resultant cast were further analyzed with the one-way ANOVA following Tukey Test. Group A was significantly different with other groups ($p \leq 0.05$) where the accuracy was distinct. On the other hand, there is no significant difference of accuracy among group B, C and D ($p \geq 0.05$) where the accuracies were similar. Comparing between direct techniques, group D was more accurate.

DISCUSSION

Evaluation of splinting two impression copings during impression taking was conducted in this study by measuring the horizontal differences between the master and resultant casts. Comparison of horizontal differences between direct and indirect techniques was also measured. In this set-up, both fixtures were placed parallel to one another to eliminate the effect of angulations. Horizontal differences were measured using a digital caliper and by a single examiner. Inaccuracies of measurements were eliminated with this digital device, however, manual deficiencies such as the positioning of the caliper to its reference points could not be avoided. Hence, non-contacting scanner would be more suitable to measure the differences.

Various implant impression techniques have been advocated and tested for their accuracy, but the results are controversial[4-14]. There are several factors that would affect the accuracy of the techniques, including the impression material of choice and the distance between fixtures. It would also be important to note that most of earlier studies were done on a custom-made metal cast. The situation in this study is a simulation of a free end saddle situation. Therefore it could serve as guidance on choice of impression techniques for the clinicians when similar situation is encountered.

Arguably, splinting of impression copings using dental floss and AAR would decrease the degree of micro-movements between copings. Therefore, rotations of the copings that would change the distance between copings should be eliminated. This would logically lead to an accurate transfer of the copings to the resultant cast. However, shrinkage of AAR during its polymerization should not be ignored. Indeed, splinting of the impression copings gave no statistically significant difference to the accuracy of the implant impressions. This finding coincides with studies by Humphries *et al.* and Herbst *et al.*[8,13,17]. It should also be recognized that Splinting would also take up a lot of chairside time.

This study has shown that a direct technique is superior to an indirect technique and is supported by Barrett *et al.*[11]. The distortion with indirect technique might occurred during the transfer of the copings to the impression body.

Table 2. *Distribution of horizontal movements (changes in distance) for each group*

Changes in distance (µm)	*Frequency*			
	Group A Mean = 67.83µm	*Group B Mean = 30.33µm*	*Group C Mean = 33.33µm*	*Group D Mean = 21.83µm*
-30 - -21	-	1	-	-
-20 - -11	-	1	3	-
-10 - -1	-	1	-	3
0 - 9	1	-	-	-
10 - 19	2	1	2	5
20 - 29	-	2	1	4
30 - 39	-	7	5	8
40 - 49	-	6	3	-
50 - 59	-	1	6	-
60 - 69	5	-	-	-
70 - 79	5	-	-	-
80 - 89	2	-	-	-
90 - 99	4	-	-	-
100 - 109	1	-	-	-
TOTAL	20	20	20	20

Direct technique would encounter less distortion as the copings stayed in the impression body. It has been suggested that any movements of the impression copings must be avoided during the fabrication of the resultant cast.[3,18-19].

Within this study only horizontal movements of the impression copings were measured. Further studies considering changes in vertical position and variation of fixtures angulations would be worthy of consideration in the future. The use of non-contacting devices such as lasers, for the measurements should also be considered

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MANUFACTURERS' DETAILS

- Dental study model - Osstem Malaysia Sdn. Bhd., Selangor, Malaysia
- Digital caliper - Mitutoyo 500-196, Mitutoyo America Corporation, Illinois, USA
- Light cured acrylic resin - Megatray, Megadenta GMBH, Radeberg, Germany
- Impression material Impregum - Penta™ Soft, 3M ESPE Dental Products, Medizin, Germany
- Impression coping - Osstem Malaysia Sdn. Bhd., Selangor, Malaysia
- Dental floss - Oral-B® California, USA
- Autopolymerizing acrylic resin - Duralay, Reliance Dental Mfg. Co, Worth, IL
- Sectional disc - KVN International, Inc., Pennsylvania, USA
- Laboratory analogs - Osstem Malaysia Sdn. Bhd., Selangor, Malaysia
- Disinfectant - Perform®, Schülke & Mayr UK Ltd., South Yorkshire, United Kingdom
- Dental stone - BegoStone plus, Bego, Breman, Germany
- Vacuum mechanical mixer EasyMix, Bego, Breman, Germany
- Vibrator - Vibramaster, Knebel Dentarios Products Ltd., RS, Brazil

ADDRESS FOR CORRESPONDENCE

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