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RESEARCH ARTICLE

COMPARISON OF THE DIMENSIONAL ACCURACY OF SPLINTED AND UNSPLINTED IMPRESSION TECHNIQUES FOR MULTI-UNIT ABUTMENT- AN INVITRO STUDY

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ABSTRACT

Aims: The purpose of this study was to compare the dimensional accuracy of splinted and unsplinted impression techniques for the multiunit abutment. **Methods and Material:** A 3D transparent acrylic model with 4 implants (2 straight and 2 angulated) and 4 multiunit abutments was fabricated. A total of 26 polyether (aquasil ultra monophase) impressions of this model were made with pick-up type multiunit impression copings. Out of this, 13 impressions were made by splinting the copings and the remaining 13 impressions were made without splinting. The horizontal distance between the abutments on the casts obtained by both techniques was measured using a digital vernier caliper. These measurements were then compared with the master model measurements. **Results:** The dimensional accuracy of splinted impression technique was almost similar to that of the 3D die whereas the dimensional accuracy of the non-splinted impression technique was less when compared to that of the 3D die. This difference in the dimensional accuracy of splinted and non-splinted impression techniques was found to be statistically significant. **Conclusions:** The study concluded that the splinted technique produced more accurate master casts than the non-splinted technique for multiunit abutments.

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INTRODUCTION

Dental implants not only restore function and appearance by replacing lost teeth, but they also boost a person's confidence, enabling them to participate in social activities.[1] The primary goal of an implant-supported prosthesis is to fabricate a superstructure that fits precisely and passively on the abutments. To obtain a restoration with a passive fit, an accurate recording of the spatial position of the implants is required. Hence an accurate impression is mandatory for the success of implant-supported dental prostheses.[2] There are two types of implant level impression techniques: open tray and closed tray impression. In closed tray impression technique, error can occur on reinsertion of the impression posts.[3] Hence, the open tray impression technique is preferred over closed tray especially in case of a larger number of implants, non-parallel implants and in edentulous patients.[4]

The open tray technique can be further subdivided into splinted and non-splinted techniques. Splinting the impression copings avoids the rotational movement of these copings in the impression material during analog fastening. Therefore, it is recommended for multiple implants to reduce distortion and improve implant stability.[5] Various authors shared differing views on the splinted and unsplinted techniques. While one research indicates that splinted impression copings with auto polymerizing resin provide a more accurate definitive cast, another study concludes that the splinted approach produces greater variation from the master model than the unsplinted technique.[6,7] Recent advancements in implant dentistry recommend the use of multiunit abutments. This abutment allows for a disangulation of up to 40 degrees in the "All on four" concept (where implants in the posterior area are positioned at an angulation). By employing this abutment the screw access holes can be optimally positioned, and a suitable path of the draw can be produced for providing a passive fit of the frameworks used in partial- and full-arch prostheses. This helps to simplify the prosthodontic reconstruction procedure.[8] Thus, this study is conducted to compare the dimensional accuracy of splinted and unsplinted techniques using open tray for multiunit abutments.

MATERIALS & METHODS

This in-vitro study was carried out in The Department of Prosthodontics, The Oxford Dental College, Bengaluru. The measurements on the master cast and on the casts obtained from splinting and non-splinting methods were made using digital vernier caliper in the Department of Physics, Oxford college of engineering. The 3D printed transparent acrylic die that incorporated four replica implants, in the canine and molar region, bilaterally, was used as a master cast. The implants in the canine region were parallel to the vertical axis and the implants in the molar region were distally inclined to the vertical axis. Straight multi-unit abutments were placed over the anterior implants and tightened with a hexagonal screwdriver until resistance was felt. 30-degree multi-unit abutments were placed on the posterior implants and tightened. (Fig.1).

Figure 1. (a) 3D print die with two parallel and two distally inclined implants (b) multiunit abutments screwed onto the implants

A 5mm thick wax spacer was uniformly adapted to the implant reference model (Fig.2a). The implant reference model and the wax spacer were duplicated using alginate impression material and poured in die stone to ensure uniform thickness of spacer for all custom trays. To fabricate a custom tray the self-cure acrylic was mixed according to the manufacturer's instructions and applied with a uniform thickness of 3mm to the duplicated cast. Twenty-six custom trays were constructed using the duplicated cast (Fig.2b).

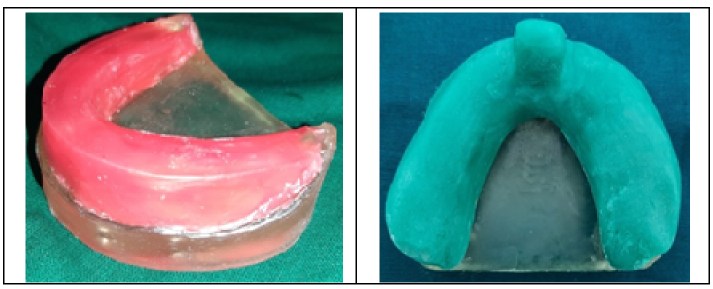

Figure 2. (a) Wax Spacer (b)Custom tray

Three location marks were made on the master cast to standardize tray positioning each time during impression making. Perforation of the tray was done to create an opening to allow access to the connecting screws of the impression post according to the principles of the open-tray impression technique.

Non-splinting technique: Multi-unit open tray impression posts were fixed to the multiunit abutments on the master die. Tray adhesive was then applied evenly over the inner surface of the tray to extend approximately 2mm onto the outer surface along the periphery and then allowed to dry for a few minutes following the manufacturer's instructions. A part of the aquasil monophase material was meticulously syringed around the impression copings to ensure complete coverage of the copings and the remaining material was loaded onto the impression tray. The tray was then seated on the master die with gentle pressure and allowed to set (Fig3). The impression tray was kept in position with hand pressure throughout the setting time. Five minutes were allowed for the setting of the impression material. The guide pins were removed so that the transfer copings remained in the impression when the tray was removed from the transparent model.

Figure 3. Impression making

Splinting technique: For the splinting technique, after the impression posts were fixed to the multiunit abutments, they were splinted using floss and pattern resin. The dental floss was wounded around each post in a figure of eight pattern to interlock the transfer-coping complex. Adequate amounts of powder and liquid were dispensed into the respective mixing cups. A small amount of pattern resin powder was picked with the brush that was previously moistened with the monomer liquid. The resin bead formed was then deposited on the floss. This was repeated until the entire surface of the floss was covered with a thin layer of pattern resin (Fig 4). Once the resin splint was polymerized, an open tray impression was made with the aquasil monophase material.

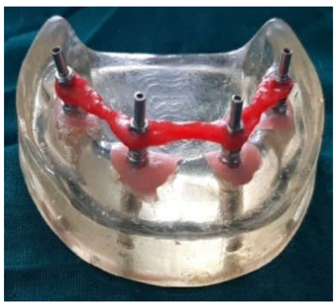

Figure 4. Splinting the impression posts using pattern resin

Attachment of analog: After the setting of impression material, the tray was gently retrieved along with the impression posts. The multiunit implant analogs were attached to the impression posts and tightened using a hex driver (Fig 5 a,b). The impression was then poured with die stone following the manufacturer's instructions. Once the die stone was set, the cast was gently retrieved from the impressions (Fig 5c).

(a)

(b)

(c)

Figure 5. (a) Open tray implant impression (b) Multiunit implant analogs attached to the impression posts (c) Cast poured using die stone

A total of 26 casts were poured which were grouped as follows; Group I - 13 casts obtained from unsplinted open tray impression technique

Group II - 13 casts obtained from splinted open tray impression technique

Testing of the sample: The ti-base abutments were screwed onto the implants on the master die. The abutment in the right molar region was labeled A, the abutment in the right canine region was labeled B, the abutment in the left canine region was labeled C, and the abutment in the left molar region was labeled D. A digital vernier caliper (LC=0.01mm) was used to measure the horizontal distance between A and B, B and C, and C and D(Fig 6 a)). The first striations of the abutments were used as a reference to standardize the measurements. The measurements were then made on the 26 samples obtained by splinting and non-splinting methods. The ti-base abutments were screwed to the analogues embedded in the casts (Group I and Group II) and tightened. By using the first striations as the reference, the measurements were made similar to those made on the master cast (Fig 6 b).

(a)

(b)

Figure 6. Measurements (a) on the 3D master die (b) on the test sample

The data for all the measurements were stored in an Excel table (Microsoft Office 365; Microsoft Corp., Redmond, WA), and the mean and standard deviation of the measurements were calculated for each group. These measurements were compared to the measurements calculated on the reference resin model which served as control. Descriptive and inferential statistical analyses were carried out in the present study. Results on continuous measurements were presented on Mean □ SD. Level of significance was fixed at p=0.05 and any value less than or equal to 0.05 was considered to be statistically significant. Student t tests (two tailed, unpaired) was used to find the significance of study parameters on continuous scale between two groups. The Statistical software IBM SPSS statistics 20.0 (IBM Corporation, Armonk, NY, USA) was used for the analyses of the data and Microsoft word and Excel were used to generate graphs, tables etc.

RESULTS

Table 1 shows the Comparison of A-B measurements in terms of {Mean (SD)} among both the groups using unpaired t-test. The dimensional accuracy of splinted impression technique was almost similar to that of the 3D die whereas the dimensional accuracy of non-splinted impression technique was less compared to that of the 3D die. This difference in the dimensional accuracy of splinted and non-splinted impression techniques was found to be statistically significant using the unpaired t-test (p value: 0.041).

Table 1. Comparison of A-B measurements in terms of {Mean (SD)} among both the groups using unpaired t test

Group	N	Mean	Std. Deviation	t value	P value
Splinting	13	23.5646	0.08058	2.161	0.041*
Non Splinting	13	23.4392	0.19307		

Table 2. Comparison of B-C measurements in terms of {Mean (SD)} among both the groups using unpaired t test

Group	N	Mean	Std. Deviation	t value	P value
Splinting	13	22.2669	0.06957	2.256	0.033*
Non Splinting	13	22.2138	0.04857		

Table 3. Comparison of C-D measurements in terms of {Mean (SD)} among both the groups using unpaired t test

Group	N	Mean	Std. Deviation	t value	P value
Splinting	13	22.9092	0.19788	2.191	0.038*
Non Splinting	13	23.0800	0.19954		

(p < 0.05 - Significant*, p < 0.001 - Highly significant**)

Table 2 shows the Comparison of B-C measurements in terms of {Mean (SD)} among both the groups using unpaired t-test. The dimensional accuracy of splinted impression technique was almost similar to that of the 3D die whereas the dimensional accuracy of non-splinted impression technique was less compared to that of the 3D die. This difference in the dimensional accuracy of splinted and non-splinted impression techniques was found to be statistically significant using the unpaired t-test (p value: 0.033).

Table 3 shows the Comparison of C-D measurements in terms of {Mean (SD)} among both the groups using unpaired t-test. The dimensional accuracy of splinted impression technique was almost similar to that of the 3D die whereas the dimensional accuracy of non-splinted impression technique was less when compared to that of the 3D die. This difference in the dimensional accuracy of splinted and non-splinted impression techniques was found to be statistically significant using the unpaired t-test (p value: 0.038).

DISCUSSION

Due to recent advances in implant technology, the development of several techniques, and materials and because of long-term success, implants have become the most preferred treatment option for the rehabilitation of patients with edentulism.[9] For the long-term success of the implant prostheses, there should be minimal stress along the implant and the surrounding tissues. This is achieved by the passive fit of the prostheses superstructure on the implant abutments.[2] The compromised fit between the contacting surfaces in the implant-supported prostheses might create uncontrolled strains in the prosthetic components and peri-implant tissues. This unnecessary strain can lead to several biological and technical complications. The technical complications include screw loosening, implant fracture, prosthodontic component fractures, and occlusal inaccuracies.[10] The marginal discrepancy due to improper fit of the restoration can cause accumulation of plaque leading to inflammation of the tissues. All this will lead to the loss of oss-eointegration and ultimately to the failure of prosthetics.[11] The first step in ensuring the passive fit is to make an accurate impression, to transfer the 3-dimensional positions of implants into the laboratory models. Several factors like impression material, impression technique, splint material, number, and angle of the implants affect the accuracy of the impression.[9]

Among the various impression materials used for recording implant impressions, polyvinyl siloxane and polyether are the most common. Polyether has been recommended for implant impressions because of its good dimensional stability, rigidity, tear-resistance, and hydrophilicity. For this research only one type of impression material was chosen, as the main focus of the study was to evaluate the accuracy of the transfer technique rather than the effect of the impression material on the accuracy.[2] Various impression techniques have been suggested, among which the open tray impression technique and closed tray impression technique are the most common. The closed-tray impression is also known as an indirect impression. In this technique, after removal of the impression, the coping is unthreaded from the mouth and repositioned into the impression. This technique is limited to situations where the implants are parallel to each other.[12] The open tray technique on the other hand is indicated, when the implants are not sufficiently parallel to allow an impression to be withdrawn from multiple impression copings. This technique uses a custom tray with openings that correspond to the implant locations so that the impression post can be unscrewed in the polymerized impression.[13]

Studies have shown that the open tray technique is more accurate than the closed tray as errors can occur while removing and replacing impression copings, especially in the occluso-gingival direction.[14,15] In this study, the open tray impression technique was performed due to the presence of unparallel implants. The open tray impression technique can be carried out either by splinting the implants or without splinting. Splinting is a common practice of joining the transfer copings with a rigid material. It helps to obtain additional stability of the connected copings in the impression when the abutment analogs are fastened. Some of the commonly used splinting materials include impression plaster, dental floss, pattern resin, auto-polymerizing polymethyl methacrylate, addition silicone, or polyether-based bite registration material. In the present study auto-polymerizing acrylic resin was used for splinting the multiunit impression copings.[16] Several studies were carried out to assess the dimensional stability of splinting and non-splinting techniques, but the results obtained were not consistent. Humphries et al and Spector et al found no significant difference between splinted and non-splinted techniques.[17,15] On the other hand, the studies conducted by Branemark et al and Assif et al revealed that when the transfer copings were splinted with acrylic resin, the casts obtained were more accurate.[18,19]

Several methods have been adopted to evaluate the implant impression accuracy, including profile projectors, vernier calipers, micrometers, optical scanners, coordinate measuring machines, strain gauges, etc.[20] The present study measured the dimensional accuracy of splinted and unsplinted impression techniques for multiunit abutments using a vernier caliper. The multi-unit abutment is specially designed to rehabilitate the edentulous arches in the all-on-4 treatment concept. The all-on-four treatment concept was developed to treat the atrophic jaw in patients who do not prefer surgical procedures like bone augmentation, nerve repositioning, etc.[21] In this concept, the posterior implants are distally tilted to enable the placement of longer implants without damaging the critical structures such as the mandibular nerve, foramen mentale, and the maxillary sinus.[22] The multi-unit abutment is set apart from the regular abutments due to its unique features like a short cone for limited interocclusal space, a wide shoulder for easy positioning of the prosthetic restoration, etc.[23] It allows great variability in the angles between splinted implants, which facilitates prosthetic reconstructions.[24] For various soft tissue anatomies − both straight and angled (0°,17°,30° and 45°) variants are available in several different collar heights.[23]

In the present study, the master cast incorporated two parallel implants anteriorly, and two distally inclined implants posteriorly to simulate the all-on-4 concept. Straight multiunit abutments were fixed to the parallel implants and angled multiunit abutments were fixed to the distally inclined implants. The impressions were made using splinted and unsplinted impression techniques. The results of this study showed that the casts obtained from the splinted impression technique were more accurate. The angled MUAs accompanied by metal collars of uneven heights allowed change in the direction of impression copings making it parallel to the vertical axis. This facilitated the splinting process leading to accurate transfer of the impression.

CONCLUSION

- The dimensional accuracy of splinted impression technique was almost similar to that of the 3D die
- The dimensional accuracy of non-splinted impression technique was less compared to that of the 3D die.
- There was significant difference in the dimensional accuracy of the splinted and non-splinted technique.

Within the limitations of this study, it was concluded that the splinted technique produced more accurate master casts than the non-splinted technique for multiunit abutment.

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