Original Article

Comparison of Dimensional Accuracy between Open-Tray and Closed-Tray Implant Impression Technique in 15° Angled Implants

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KEY WORDS
Implant; Impression; Open Tray; Closed Tray; Dimensional Changes

ABSTRACT

Statement of Problem: Various impression techniques have different effects on the accuracy of final cast dimensions. Meanwhile, there are some controversies about the best technique.

Purpose: This study was performed to compare two kinds of implant impression methods (open tray and closed tray) on 15 degree angled implants.

Materials and Method: In this experimental study, a steel model with 8 cm in diameter and 3 cm in height were produced with 3 holes devised inside to stabilize 3 implants. The central implant was straight and the other two implants were 15° angled. The two angled implants had 5 cm distance from each other and 3.5 cm from the central implant. Dental stone, high strength (type IV) was used for the main casts. Impression trays were filled with poly ether, and then the two impression techniques (open tray and closed tray) were compared. To evaluate positions of the implants, each cast was analyzed by CMM device in 3 dimensions (x,y,z). Differences in the measurements obtained from final casts and laboratory model were analyzed using t-Test.

Results: The obtained results indicated that closed tray impression technique was significantly different in dimensional accuracy when compared with open tray method. Dimensional changes were $129 \pm 37 \mu m$ and $143.5 \pm 43.67 \mu m$ in closed tray and open tray, while coefficient of variation in closed- tray and open tray were reported to be 27.2% and 30.4%, respectively.

Conclusion: Closed impression technique had less dimensional changes in comparison with open tray method, so this study suggests that closed tray impression technique is more accurate.

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Introduction

Dimensional changes occur due to the contraction in the impression material which is initiated by polymerization reaction with formation of volatile materials and by-products, pressure applied during impression and conventional impression techniques. Making a precise mold of implant is necessary for passive fitness. Passive fitness is the term used to address fitting status of the implant in which implant body shows adequate fitting for simultaneous adaptation and remodeling [1].

Making a superstructure with passive fitness is one of the main objectives during implant-based prosthesis. Preparation of a precise mold with stable dimensions prior to casting is necessary to achieve this passive fitness [2]. However, failing to achieve this passive fitness will incur stress on implants which can finally lead
to fracture of the implant components and failure of the treatment. The forces created in the implant due to non-passive nature of the superstructure is able to resorb the bone surrounding the implant and cause ischemia within peri-implant tissue and subsequent healing with non-mineral tissue around the implant, mechanical fracture, loosening of the implant components and fracture of the restoration [3].

There are several methods to achieve passive fitness, although no distinct protocol has been introduced in this field yet [4]. It is now believed that the impression materials are significantly improved, so choosing the proper technique would be the main issue [3].

Recent developments in impression techniques, to obtain the maximum accuracy of the implant position, have been regarded more than other issues [5]. Some degrees of error and inaccuracy have also been noticed in the precise transfer of the implant positions for all impression methods. The most common techniques are closed-tray, open-tray which have been cited almost similarly in the literature, although angulation of the implants plays a key role in the accuracy of impression [5]. The transfer technique uses tapered copings and a closed tray to make an impression.

The copings are connected to the implants, and an impression is made and removed from the mouth, leaving the copings in the mouth. Subsequently, the copings are removed and connected to the implant analogs, and then the coping-analog assemblies are inserted in the impression before pouring the definitive cast. The clinical situations which indicate the use of the closed tray technique are when the patient has limited interarch space, tendency to gag, or if it is too difficult to access an implant in the posterior region of the mouth and angulated implants [6].

Conversely, the pick-up impression uses square copings and an open tray (a tray with an opening), allowing the coronal ends of the impression coping screw to be exposed. Before separating the implants, the copings screws are unscrewed to be removed along with the impression.

The implant analogs in the impression are connected to the copings to fabricate the definitive cast. The disadvantages of this technique could be that there may be some rotational movement of the impression coping when securing the implant analog, and blind attachment of the implant analog to the impression coping may result in a misfit of components [8].

It has been claimed by other research that the closed tray technique is more accurate for impression single implant [9]. Moreover, one other study has claimed that the closed tray technique is preferred even for three implants [10]. Indirect methods are often clinically preferred by clinicians [2, 11].

With considering mentioned contradictions, this research aims to compare two impression methods of open tray and closed tray in dimensional accuracy for 15° angle implants.

Materials and Method
The research was done through an experimental-laboratory method on 15 input samples in each group, forming a total number of 31 samples. In which each sample has 6 points (A, B, C, D, E, F). A steel model, having 8 cm diameter and 3 cm height, was produced first and then three grooves were devised for three implants (Noble Biocare; AB, Göteborg Sweden). Every two angulated implants were 5 cm apart with 3.5 cm distance from central implant. The position of implants was analyzed by the surveyor so the central implant was placed perpendicular to the casting surface while the other implants had divergence or convergence of 15° from the central component (Figure 1).

For making the main cast, dental stone, high strength (type IV, Ernest hinrichs; Germany) was used in a vacuumed mixer apparatus. The whole implant was fixed using cyanoacrylate. All operations were implemented by one operator. Trays were prepared from polymerizable acryl in visible light (megadenta; Germany) and polymerized for 6 minutes (Figure 2). The trays were then trimmed and perforated to enhance gripping of the impression material. Meanwhile, the main cast
was equipped with two guide pins in order to fit the designed tray using open tray method.

The trays were filled by polyether (IMPREGUM sm-espe; Germany), placed on the main cast and the additional material was removed by finger from the perforations to uncover pins. The impression material was allowed to be polymerized for 10 minutes before detachment (Figure 3).

In open tray technique, the guide pins were loosened using hex-driver and were removed. Then, the tray was detached from the main cast with the copings being remained in the mold, while analog of the implant was connected to the impression copings. Impression copings of the closed tray remained on the main cast after polymerization of the impression material. These copings were removed from the main cast and connected to the analog when the tray was removed. Analog units of the compound coping were placed deep in the impression by applying pressure with complete or partial clockwise rotation till a resistance against rotation was felt. This contact feeling implies that position of the implant has been correctly transferred.

The impression was examined and it was repeated when any kind of deficiency was observed including trapped air bubbles and leftovers of impression material between the coping connection and the analog. Dental stone, high strength (type IV) cast was then prepared according to instructions of the manufacturer. Casts were trimmed and coded after being cured for one hour (Figure 4).

The casts were analyzed by CMM (coordinating measuring machine) devices (DEA; Italy) in three dimensions (x, y, and z) for evaluating the position of implants and dimensional changes. Therefore, they were fixed on a mounting plate using a vise for further measurements. A fine tip stylus was then adopted to record multi-axial coordinators (x, y, z) on the upper surface of hex implant and also on the casting base. The tip of the stylus was located on the center of the hex implants and calculated for six vertices of the hex and three plans (x, y, and z). Afterwards, different vector calculations were determined, in degrees, between implant angles on both the main and the duplicate cast [11-13] (Figure 5). Statistical analysis adopted in this study was Student t-test.

**Results**

The current study was performed on a total of 31 samples which had 15 test samples in each group in addition
to six defined points (A, B, C, D, E, F). The content of
dimensional changes in transfer of implant positions
was reported to be 129±37μm for experimental groups
(closed tray) and 143.5±43.6μm for the (open tray)
(Table 1).

Thus, the values of the latter group were 14.5μm
or 11.2% greater than the former one. Results of Student’s t-test indicated that the changes for open tray
group were significantly greater than the close tray
(p< 0.001). Meanwhile, coefficients of the variations
were calculated to be 28.7% and 30.4% for the experimental
groups, respectively.

Dimensional changes in the transfer of implant
positions have been displayed in figure 6 based on the
points under study and the impression methods applied.
They show that changes in open tray method were
greater than closed tray (in all points) and it was statisti-
cally significant (p< 0.09).

**Discussion**

The obtained results indicated that closed tray impres-
sion method had lesser dimensional changes and it was
more acceptable than open tray technique.

The current study revealed that the dimensional
changes for closed tray were lesser than the open tray
impression method in the implants with 15° divergence
position. This finding contradicts with the results of the
most previous researches and the cited references.

Some studies in literature have not distinguished
the differences as significant [1, 10-11], whereas some
others have identified open tray impression method
more accurate [2]. However, dimensional changes of
closed tray technique which was lesser in this study can
be attributed to its simplicity, accuracy of operator in
implementing the technique [2, 14] and application of
custom tray instead of prefabricated tray [5]. Regarding
the inconsistent results on preference of either direct
(open tray) or indirect (closed tray) method, it seems
that the accuracy of the operator has been more effec-
tive than any other factor in final results.

Rismanchian and Moniri Fard [2] applied two me-
thods of programmed search and manual search in sev-
eral relevant journals to study articles associated with
implant impression, common methods and modifica-
tions made. They finally concluded that direct impres-
sion (open tray) method was more accurate than indirect
(closed tray) method.

Most researchers have preferred the direct me-
thods and have confined indirect techniques to single
implant applications. Although, some others have clini-
cally verified both techniques in spite of their different
statistical significance and have identified the errors as
tolerable [15].

Seyyedan et al. [1] had noticed passive fitness as
one of the prerequisites of implant supported prosthesis.
They did not distinguish a significant difference be-
tween open tray and closed tray techniques. Also angu-
lations of the implants were not mentioned in their re-
search [1].

Based on the study enrolled by Carbal and co-
workers which analyzed four different impression tech-
Techniques for implants; different methods were investigated and compared concerning their dimensional accuracy [15]. The results were compared with standard technique of this research and did not reveal a significant relationship between the two impression methods of direct and indirect. Their research also failed to consider angulations of the implants.

Based on a research enrolled by Heather et al.; accuracies of two impression techniques, namely open tray and closed tray, were not significantly different ($p = 0.22$) [16]. They also noticed that implant angle and implant number were different from average error of angulations but not large enough to be simply interpreted ($p > 0.001$). Various angles of 5°, 10° and 15° were experienced in their research although the measurement time after casting and the software used were not verified.

The study of Daudi et al. investigated the accuracy of the two impression techniques for single implants in laboratory [17] and focused on the accuracy of four impression processes of implants through direct and indirect methods; using poly ether and poly vinyl siloxane materials. The SAS software was utilized in their work which identified the indirect method as more preferable.

Walker et al. worked on the accuracy of implant casting as a function of impression technique and viscosity of the impression material [18]. They demonstrated that casts built through closed tray (indirect) method with metallic copings on the surface of the implant were more accurate than the casts fabricated by open tray (direct) method with plastic copings.

Current study has benefited from the best 3-D measurement equipments with the highest possible resolution in small dimensions. One instance is using the coordinating measurement tools such as CMM [1, 5].

A significant difference was observed in this research between straight and angulated implants. Angulated implants incur a great stress to the impression materials once the molds are being removed out of mouth which can cause permanent deformations in these materials.

Most research has focused on the accuracy of techniques with parallel implants [19-31] but nonparallel implants are commonly encountered in clinical situations. For this reason, the investigators evaluated the nonparallel condition, with some finding no significant difference between the accuracy of the closed tray technique and unsplinted open tray technique at up- to -15 degrees of angulation was seen [32-33].

Humphries et al. reported that the closed tray technique yielded a higher correlation to coordinate values on the definitive cast than open tray technique [19].

As cited previously one of the indication of close tray technique is angulated implants [6-7]. In this study angulation between inclined implants was 30 degrees, so these angulations may cause greater stress to the impression material once the tray is removed and generated lesser dimensional accuracy in casts in unsplinted open tray technique in comparison to close tray technique.

Comparing the results of experimental and semi-experimental studies, researchers have chosen various methods and set-ups. The difference in designing experimental models, measurement apparatus for distances under evaluation towards the reference points, and impression methods can make the comparison between these results rather difficult. Thus, it seems necessary to implement in vivo studies on this field to provide increased clinical generalization and reach the most accurate and the simplest impression methods for dental implants.

**Conclusion**

With considering the limitations of this research, closed-tray impression method on angulated implants seems to have a significant effect in reducing the dimensional changes in comparison to open tray method. Therefore, closed tray method is recommended due to its more simple application and lower impression time.

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