The effect of implant placement depth and impression material on the stability of an open tray impression coping.

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Abstract: Purpose: to measure the effect of implant depth and type of impression material on the stability of open tray impression coping. Materials & Methods: Four single implant analogs were placed in four acrylic master models with different depths (1mm, 2mm, 3mm & 4mm). Custom made tray were constructed for each model for taking impressions. Twenty implant level impressions were taken by polyether impression material, five impressions for each group and same procedure was repeated for VPS impression material. A device with compression force gauge was used to test the stability of the dental implant analog. The value of the force needed to move the implant analog connected to the impression coping by 1.0 mm was displayed on the force gauge monitor in Newton (N). Data was collected and statistically analyzed. Results: In both materials, a mean greater force was observed at 1mm depth, with a gradual decrease in the mean force associated with increase in depth. The lowest mean force was found at 4mm. At all depths, greater mean compression force was required in the polyether impression material. Two-ways ANOVA test revealed a statistically significant difference (P=0.002). Tukey's post hoc test revealed a significant difference between each two depths in both materials. Conclusion: within the limitations of this study, implant placement depth and type of impression material affects the stability of open tray impression coping.
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Key words: implant placement depth, VPS impression material, Polyether impression material, open tray impression coping, implant analog.

1. Introduction

Subgingival positioning of a single dental implant, impression material used and type of tray may result in a less stable impression coping in a polymerized impression material. The primary objective in fabricating a superstructure for osseointegeratedendosseous implants is to achieve a passively fitting connection between an implant abutment and the framework [1]. It is accepted that the fit of a restoration can be considered "passive" or "strain free" if it does not create static loads within the prosthetic system or in the surrounding bone tissue [2].

Prosthetic misfit is likely to increase the incidence of mechanical complications, like occlusal discrepancies, screw, and abutment loosening and fracture of the prosthetic or implant components [3].As to biologic complications, the effect of misfit on the bone tissue around the implants is still controversial but yet, it might enhance plaque accumulation, affecting soft and/or hard tissues around the implants [4].

Ideally, the implant platform adjacent to a natural tooth should be positioned at the crestal bone level, 2 to 3 mm apical to the free gingival margin at the facial aspect, to maintain both biologic width and an adequate prosthetic space. This will create a smooth transition from the round implant platform to the natural root and scalloped cervical anatomy [5].

Subcrestal position of dental implants has been proposed to decrease the risk of exposure of the metal top of the implant or of the abutment margin, and to have sufficient space in a vertical dimension to create a harmoniously esthetic emergence profile[6].

It has been suggested that the subcrestal positioning of the implants may have some positive influence on the maintenance or formation of a crestal bone peak in the interimplantregion [7].The presence of bone slightly over the top of the implant could play a beneficial outcome in the esthetic regions [8].

The procedure of impression taking for a subcrestal implant requires the placement of a part of the impression coping below the gingival margin. Consequently, there is a decrease in the portion of the coping which is supragingivally exposed. This reduction in the exposed surface of the impression coping may lessen the stability of the impression coping in the impression material and, therefore, affect the accuracy of the impression [9].

The accuracy of the definitive cast is dependent on the type of impression material used, the implant impression technique and the accuracy of the die material [10,11,12].

As for the impression materials, there are several elastic impression materials available for reproducing oral conditions in order to construct the restorations [13]. With proper material selection and manipulation, accurate impressions can be obtained for fabrication of tooth implant supported restorations. Most of the impression materials available today provide superb accuracy if they are manipulated correctly [14].

Within the various impression materials present in the market, polyether and vinylpolysiloxane (VPS) were the most frequently tested [15].

Polyethers and addition silicones have been used for many years as impression materials and have gained popularity because of their excellent accuracy, dimensional stability and quick recovery. These impression materials have been modified with the addition of plasticizers and fillers. Large amount of catalyst has been also added in order to accelerate their polymerization reaction [16].

Impression techniques are particularly important in the fabrication of accurate working casts [17]. The development of impression techniques to accurately record implant position has become more complicated and challenging. Several impression techniques have been suggested to obtain a master cast that will ensure the passive fit of prosthesis on implants[18].Two commonly used implant impression techniques are the closed tray and the open tray techniques[19].

The open tray (Direct or Pick-up) technique uses square impression copings and an open tray (a tray with an opening). This technique involves fastening the implant with the impression coping screw where the coronal end of the screw projects through the opening in the tray to be exposed inside the oral cavity. Directly after the impression material sets, the screw is loosened and removed from the coping. Then the impression tray is removed from the mouth with the impression coping retained within the impression. An implant analog is fastened to the impression coping using the same screw. The open tray technique maintains the coping inside the impression avoiding the need to remove the coping and manually repositioning it inside its place in the impression. Disadvantages of this technique are that there are more parts to control when fastening, 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[14,20,21].

Conversely, the closed tray (Indirect or Transfer) technique uses a tapered impression coping and a closed tray to make the impression. The copings are connected to the implants, the impression is made and removed from the mouth after setting leaving the copings intraorally. 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 [15,21,22].

Despite being less difficult clinically but its maindisadvantage is the difficulty to ensure repositioning of the impression copings exactly into their respective positions in the impression, otherwise, misfits will occur. Also it has been shown that the closed technique had greater instability in transferring the implant position as well as producing greater mean distortion than direct techniques [20]. Supporters of the closed tray technique suggest that it is more reliable than open tray technique as the visual fastening of the analog to the coping is more accurate [20].

However, there may be clinical situations which indicate the use of the closed tray technique, such as in patients with limited inter-arch space, a tendency to gag, or if it is too difficult to access an implant in the posterior region of the mouth [22].

Thus, the design of transfer coping and the tray are the main differences between both techniques where squared transfer copings and open tray are applied for direct transfer technique, whereas indirect technique is performed with tapered transfer copings and closed tray [23].To date, the various implant impression techniques have been investigated for accuracy; however, the results were not always consistent [15].

2. Materials and Methods

In the present study four cubic acrylic master models were constructed, one for each experimental group. In each of the 4 master models, one implant analog was inserted in the center of the model.

Four custom open trays were constructed, one for each master model. The design of the custom trays was square in shape to fit onto the master models.

Four implant analogs are then placed into the blocks and fixed in place using cyanoacrylate adhesive (Power Alpha, Egypt) so that each implant analog is placed with the required depth as follows 1mm, 2mm, 3mm and 4mm below the top surface of the model. **Fig. (1)**

Then for each master model, the impression copings were adapted and fastened to the implant analogs using the coping screw. **Fig. (2)**

Two impression materials were used for each group, polyether and addition silicone.

Twenty implant level impressions were taken by polyether impression material, five impressions for each group and same procedure was repeated for VPS impression material.

Hand Force was applied and maintained on the tray until the tray was completely seated on the step of the master model. Excess impression material extruded out from the holes of the trays.

By seating the open tray on the master model, the coronal end of the pick-up coping screw projected through the occlusal opening in the tray.

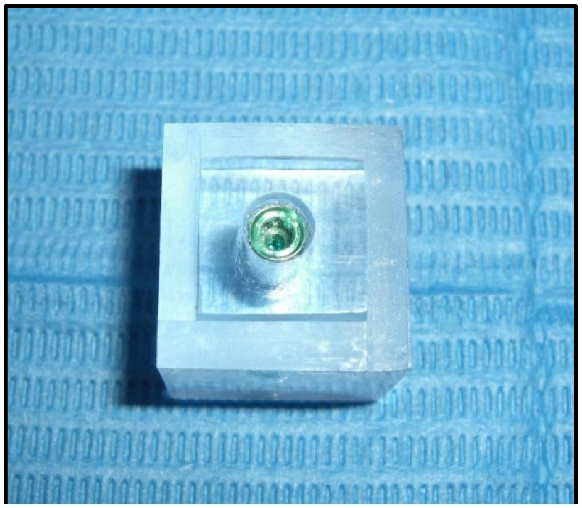

Fig.(1) implant analog placed below top surface of the model by 1mm.

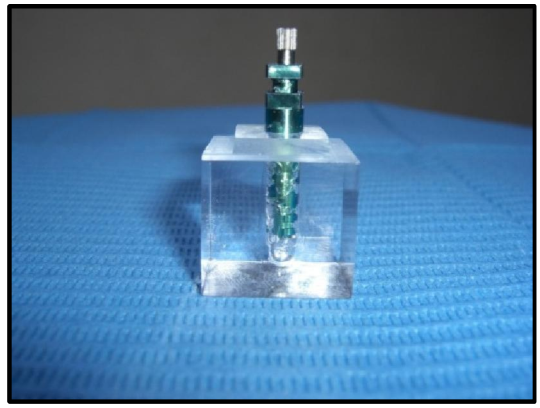

Fig.(2) open tray impression coping fastened to the implant analog

The tray was then placed and secured in a locking device. A device with compression force gauge was used to test the stability of the dental implant analog. All of the impression trays were fixed in the same position for testing. The pole of the force gauge was oriented to touch the surface of the implant analog in the same area. ***Fig. (3)***

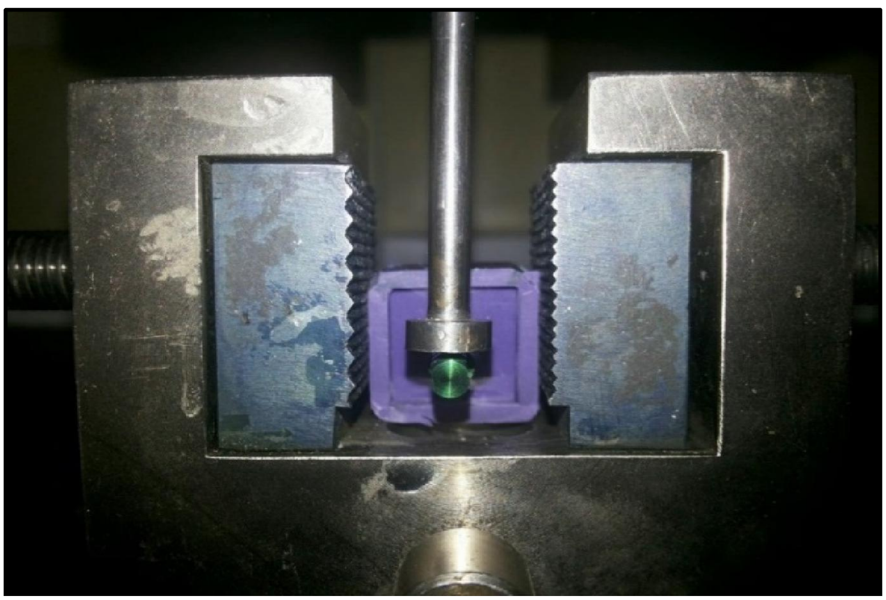

Fig.(3) compression force guage was oriented to displace the implant analog 1mm.

The measuring device was programmed to stop after moving the implant analog connected to the open tray impression coping by 1.0 mm with a constant speed 2mm/min. Measurement was repeated 5 times with each model. The value of the force needed to move the implant analog connected to the impression coping by 1.0 mm was displayed on the force gauge monitor in Newton (N).

Data was collected and statistically analyzed.

3. Results

In both materials, a mean greater force was observed at 1mm depth, with a gradual decrease in the mean force associated with increase in depth. The lowest mean force was found at 4mm. At all depths, greater mean compression force was required in the polyether impression material. Two-ways ANOVA test revealed a statistically significant difference (P=0.002). Tukey's post hoc test revealed a significant difference between each two depths in both materials **(Fig.4).**

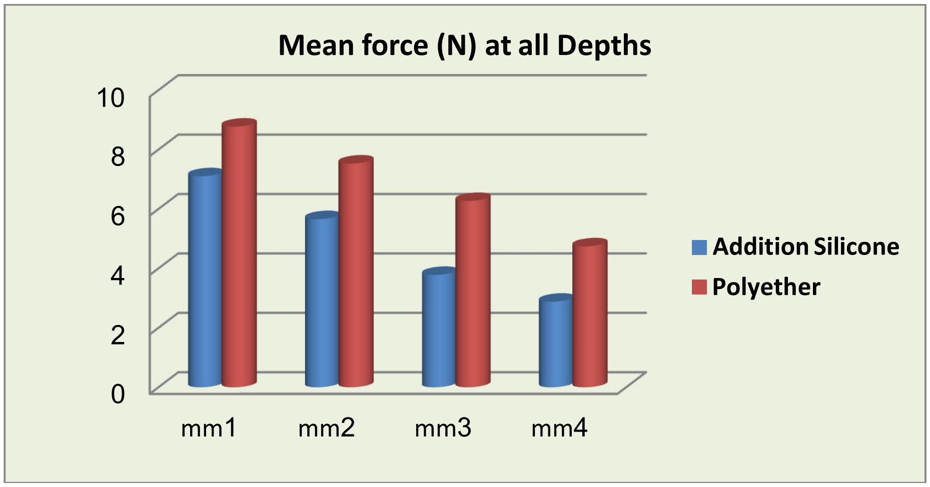

Fig.(4): Two-ways ANOVA test revealed a statistically significant difference (P=0.002). Tukey's post hoc test revealed a significant difference between each two depths in both materials

4. Discussion

The fidelity of the cast obtained from an implant impression requires the desirable association of sound impression materials, with effective impression transfer techniques, to accurately register the implant position and its relationship with adjacent and antagonist teeth [(24)].

The selected impression materials for this study were two of the most popular impression materials used in recording intraoral tissues which are medium consistency polyether impression material and medium consistency addition silicone impression material (VPS) [(25)]

In the present study, Implant analogs were substituted in the master models for implants because they are exact replicas for the implants having the same dimensions, internal connection design with the advantage of being cost saving[(26)].

Regarding the effect of implant placement depth, the results of the present study revealed that a mean greater force was observed at 1mm depth, with a gradual decrease in the mean force associated with increase in depth whereas the implant placement depth increased, the force needed to move the open tray impression coping decreased with both impression materials. Thus the stability of the open tray impression coping in a polymerized impression material also decreased. The smaller the portion of the open tray impression coping that was covered with an impression material, the less stable was the impression coping.

This was in accordance with Linkevicius *et al.*[(27)] who stated that a negative correlation was shown between the depth of implant placement and the force needed to move the implant analog connected to the coping. In each tested material, if the implant placement depth increased, the stability of the coping decreased.

Also this was in accordance with Lee *et al.*[(9)]who stated that an increased implant depth had a negative effect on the accuracy of impressions made with a polyether medium body material. It was also hypothesized that extending the impression coping provides additional retention and resistance to displacement.

Also the results showed that at all depths, greater mean compression force was required in the polyether impression material than in the addition silicone impression material to move the impression coping 1mm in lateral direction.

This was in accordance with the findings of Wee [(10)] who measured the amount of torque required to rotate an impression coping in impressions. Hetested the torque resistance of impression materials and found that polyether had the highest overall torque values followed by addition silicone. The rigidity of impression materials was measured by evaluating the amount of torque required to rotate a square impression coping in the polymerized impression.

Also Perry *et al.*[(28)] found that polyethers had higher torque strength than addition silicones. Higher torque strength, which decreases implant rotation, is an advantage when removing intra-oral impressions.

On the other hand the results were against Lu *et al.*[(29)] who tested the mechanical properties of 3 hydrophilic addition silicone and polyether elastomeric impression materials and found that the addition silicones were stiffer than polyether impression materials tested. This was based on the fact that higher strain in compression values indicates more flexibility.

And Link evicius *et al.* [27] who found that the VPS materials provided more stability for the impression coping than those of the polyethers.

And this can be attributed to the use of different impression materials in their studies, testing methods or impression handling techniques than those used in the present study.

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