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

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Statement of problem. Subgingival positioning of a single dental implant may result in a less stable impression coping in a polymerized impression material.

Purpose. The purpose of this study was to evaluate the influence of a single dental implant placement depth and different impression materials on the stability of an open tray impression coping.

Material and methods. Six polyvinyl chloride-based plastic models with single embedded internal hexagon implant analogs were fabricated. The implant analogs were placed equally with their surface 0, 1, 2, 3, 4, or 5 mm below the simulated gingival margin. Open tray impression copings were connected to the embedded implant analogs, and impressions were made with different vinyl polysiloxane (VPS) impression materials, polyethers, and an addition silicone-based occlusal registration material. The laboratory analogs were connected to the impression copings and the plastic trays were placed in a locking device. A measuring device, consisting of a compression force gauge connected to a platform moving at a speed of 3.2 mm/s, was fabricated. The impression trays were fixed so that the pole of the force gauge would touch the surface of the implant analog in the same place and push it 1.0 mm. Measurements of each specimen were made 5 times. Statistical analysis was performed with a 1-way ANOVA, the Tukey test, and the Pearson correlation coefficient (α=.05).

Results. There was a significant negative correlation between the dental implant placement depth and the force needed to move the impression coping (P<.05). In all depth groups, the impression coping was significantly more stable when the impressions were made with the occlusal registration material (P<.05).

Conclusions. As the dental implant placement depth increased, the force needed to move the impression coping decreased. The coping was significantly more stable when an occlusal registration material was used to make the impression. (J Prosthet Dent 2012;108:238-243)

Clinical Implications

In a situation where a single dental implant is placed deeply subgingival, the use of an addition silicone-based occlusal registration material together with a VPS impression material may be beneficial for the direct implant impression technique.

The first step in fabricating a precision dental implant-supported restoration is making an accurate impression.[1,2] The accuracy of dental impressions is influenced by a number of factors, including dental implant angulation, the number of implants, use of coping splinting, material choice, use of open or closed impression trays, and impression coping surface treatment with airborne-particle abrasion or impression adhesive.[3-5]

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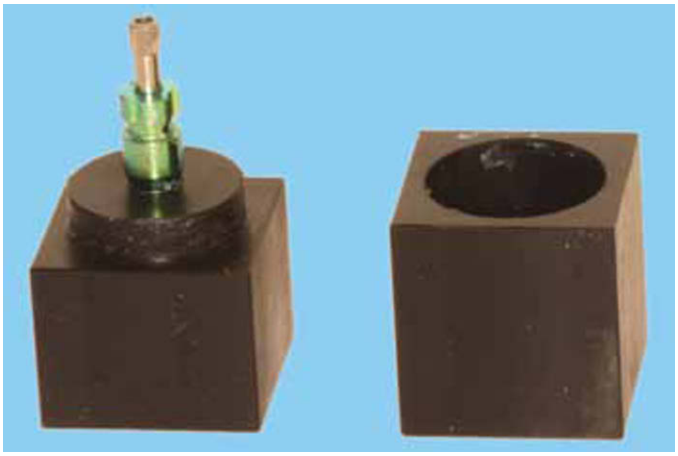
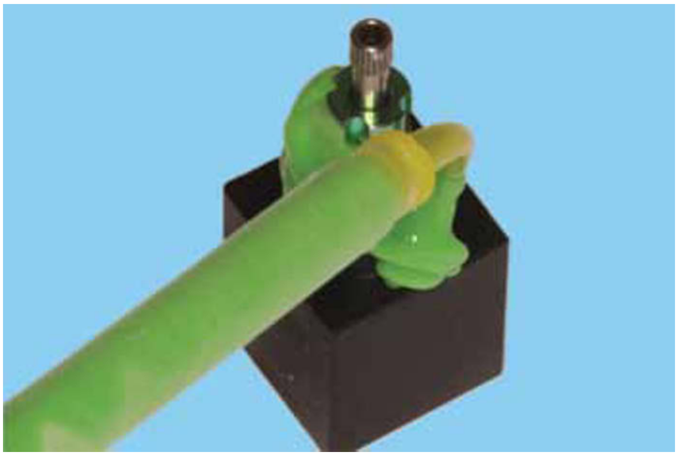


1 Plastic model with embedded implant analog with open tray coping (left) and specially designed hard plastic tray (right).



2 Impression material is placed in tray.

A special condition arises when a single dental implant has to be placed subgingivally, for example, in the anterior region, to achieve better esthetics.[6] During the making of the impression of a deeply placed single dental implant, the greatest portion of the impression coping connected to the dental implant is situated under the periimplant tissues and has limited contact with the impression material. This results in reduced stability of the impression coping in a polymerized impression material. Conrad et al[7] reported that if the coping is not stable, it is possible to rotate it when securing the dental implant analog. Wee[5] also emphasized the importance of the rigidity of an impression material when making a direct implant impression. The author stated that the impression material should hold the direct impression coping to prevent displacement of the coping when an implant analog is connected.[5] Because the main purpose of an implant impression is to record the dimensional position of the implant, accidental displacement of the impression coping in the impression material consequently leads to a less accurate definitive cast and a poorly fitting prosthesis.[5] Longer individual impression copings are recommended to increase the impression precision of subgingival implants. However, this option increases the cost of the treatment as special longer transfer caps have to be purchased. Moreover, currently, not all implant systems have such copings available.[5] Linkevicius et al[8] proposed the use of an occlusal registration material to improve the stability of the dental implant impression coping with dental implants placed subgingivally. However, the use of this material for dental implant impressions has not been thoroughly examined.

The purpose of the present study was to evaluate the influence of the dental implant placement depth and the use of different impression materials, including that of an occlusal registration material, on the stability of a single open tray impression coping. The null hypotheses proposed that the stability of an impression coping is not affected by either the choice of the impression material (1) or the implant placement depth (2).

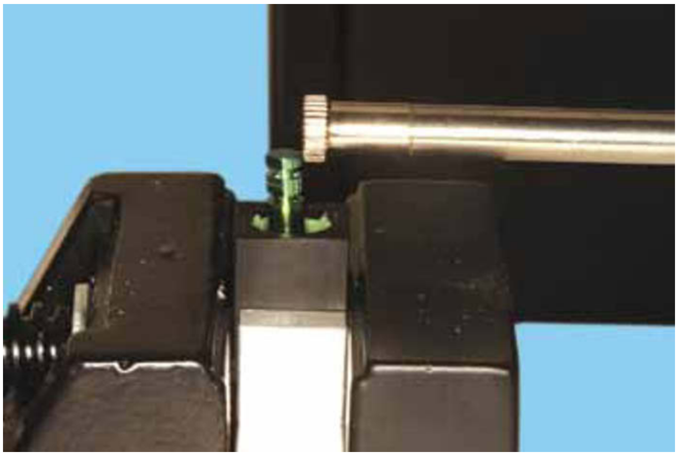
MATERIAL AND METHODS

Six polyvinyl chloride-based plastic models were embedded with a single dental implant analog (Tapered Internal Implant System; Biohorizons, Birmingham, Ala) of 4.5 mm diameter. The dental implant analogs were embedded 0, 1, 2, 3, 4, or 5 mm below the simulated gingival surface. Open tray impression copings (BioHorizons Internal; BioHorizons) were connected to each dental implant analog and firmly hand tightened. Custom impression trays were fabricated with an opening in the center, simulating the impression trays used by clinicians to make a direct dental implant impression (Fig. 1).

The impressions were made with vinyl polysiloxane (VPS), polyether, and an addition silicone-based occlusal registration material. The VPS impression materials (Splash; Discus Dental, Culver City, Calif) included 4 different viscosities: Extra Light Body (ELB), Light Body (LB), Medium Body (MB), and Putty (P). The polyethers used were Light (L) (P2 Polyether Light; Heraeus Kulzer, Hanau, Germany) and Heavy (H) (P2 Polyether Magnum 360 Heavy; Heraeus Kulzer). An addition silicone-based occlusal registration material (FD) (Futar D; Kettenbach GmbH & Co, Eschenburg, Germany) was also used to make impressions. An adhesive was applied to each tray according to the manufacturer's instructions (Universal Adhesive; Heraeus Kulzer; and P2 Polyether Adhesive; Heraeus Kulzer). All the materials were manipulated in accordance with the manufacturer's instructions. Correction impression materials were mixed with a manual gun dispenser (Dispensing Gun 2; Heraeus Kulzer). Two manual gun dispensers were used simultaneously: one to fill the tray (Fig. 2), and the other to inject the same type of ma-

3 Impression material placed on coping.

4 Tray with VPS impression material positioned on plastic model.



5 Plastic tray placed in locking device and pole of force gauge which touches surface of implant analog connected to coping.

terial around the coping (Fig. 3). VPS putty was mixed by hand and loaded inside the tray. Heavy polyether was mixed with a machine (Dynamix; Heraeus Kulzer). The trays filled with VPS, polyether, or an occlusal registration materials were positioned on plastic models (Fig. 4). After polymerization, the impression copings were unscrewed and the impression trays were separated from the models. Laboratory implant analogs (Tapered Internal Implant System; BioHorizons) were connected to the impression copings.

A device with a 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 place (Fig. 5). The measuring device was programmed to stop after moving the implant analog connected to the open tray impression coping by 1.0 mm. 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 newtons (N).

Mean and standard deviation values were calculated and a statistical analysis was performed. All of the tests had a .05 level of statistical significance, and 1-way repeated measures ANOVA was used to define the significant difference between the materials. The Tukey HSD (Honestly Significant Difference) test was performed to determine which materials in each depth group differed significantly. The Pearson correlation coefficient was used to verify whether a correlation existed between the implant placement depth and the force needed to move the implant analog connected to the open tray impression coping.

RESULTS

The mean values of force (N) needed to move the dental implant analog connected to the open tray impression coping by 1.0 mm are summarized in Table I. The Tukey test revealed significant differences ($P<.05$) among the materials in each depth group, except between ELB and H (Table I).

The results of the Pearson correlation coefficient showed a significant negative correlation ($P<.05$) between the implant placement depth and the force needed to move an implant analog connected to an open tray impression coping (Table II). The deeper the implant was placed, the smaller was

TABLE I. Mean and standard deviation (SD) values of force (N) needed to move implant analog connected to coping by 1.0 mm

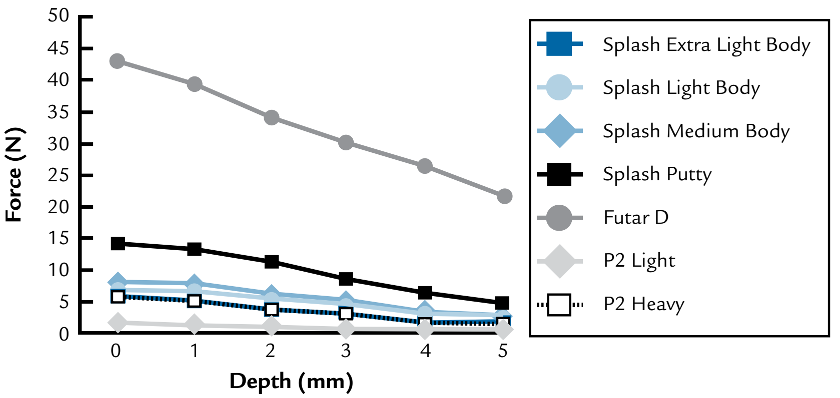
	Depth 0 mm Mean (SD)	Depth 1 mm Mean (SD)	Depth 2 mm Mean (SD)	Depth 3 mm Mean (SD)	Depth 4 mm Mean (SD)	Depth 5 mm Mean (SD)
L	1.55 (0.03)	1.37 (0.03)	0.65 (0.02)	0.52 (0.01)	0.39 (0.02)	0.39 (0.01)
H	5.91 (0.33)[a]	5.18 (0.03)[a]	3.60 (0.16)[a]	3.17 (0.06)[a]	1.63 (0.01)[a]	1.39 (0.02)[a]
ELB	6.13 (0.13)[a]	5.00 (0.13)[a]	3.96 (0.04)[a]	3.26 (0.04)[a]	1.64 (0.04)[a]	1.35 (0.03)[a]
LB	7.05 (0.14)	6.72 (0.15)	5.16 (0.10)	4.08 (0.13)	2.94 (0.07)	2.25 (0.03)
MB	7.98 (0.29)	7.78 (0.15)	5.85 (0.14)	4.94 (0.03)	3.44 (0.02)	2.61 (0.05)
P	13.98 (0.47)	13.09 (0.32)	11.48 (0.38)	8.44 (0.26)	6.49 (0.30)	4.91 (0.21)
FD	43.07 (0.58)	39.55 (0.38)	34.06 (0.37)	30.13 (0.25)	26.44(0.09)	21.60 (0.39)

Same superscripted lower case letters in same column indicate no significant difference between materials (*P*>.05).
L – Polyether P2 light, H – Polyether P2 Magnum 360 heavy, ELB – Splash extra light body, LB – Splash light body, MB – Splash medium body
P – Splash putty, FD –Futar D.

TABLE II. Pearson correlation coefficient

Material	Correlation Value (r)	*P*
L	-0.921	<.001
H	-0.982	<.001
ELB	-0.990	<.001
LB	-0.990	<.001
MB	-0.986	<.001
P	-0.986	<.001
FD	-0.997	<.001

L – Polyether P2 light, H – Polyether P2 Magnum 360 heavy, ELB – Splash extra light body, LB – Splash light body, MB – Splash medium body, P – Splash putty, FD –Futar D.



6 Influence of implant placement depth on force required to move implant analog connected to coping in different impression materials.

the force needed to move the dental implant analog connected to the open tray impression coping in each tested material (Fig. 6).

DISCUSSION

The results of the study show that an open tray impression coping was significantly more stable when an occlusal registration material was used as the impression material. Thus, the null hypothesis, stating that the stability of an impression coping is not affected by the choice of an impression material, was rejected. The occlusal registration material provided a much higher open tray impression coping stability than the VPS impression materials or the elastic polyethers.[5,9] Therefore, it can be presumed that a small amount of an occlusal registration material could be used around an open tray impression coping to increase its stability in a VPS impression material. Linkevicius et al[8] suggested using this material to obtain better stability of dental implants positioned subgingivally.

It was observed that the stability of the open tray impression coping in a polymerized impression material increased along with the increase in the viscosity of VPS or polyether impression material. The extra light viscosity VPS and the light viscosity polyether impressions yielded the least stable open tray impression copings. Therefore, the viscosity of materials for dental implant impressions should be carefully considered. Both the polyether and the VPS impression materials were inferior to the occlusal registration material in preventing open tray impression coping displacement. The occlusal registration material exhibited the highest force values in all depth groups. Thus the use of an occlusal registration material could be favorable when making impressions, especially for deeply placed implants. The hardness of the occlusal registration material could compensate for the lack of the impression material around the subgingival portion of the open tray impression coping. Therefore, it should be emphasized that this issue concerns clinical situations with single-tooth dental implant open tray impression copings. Multiple dental implant impression copings would normally be splinted together when an open top impression tray is used.

The present study showed that the stability of an open tray impression coping of a deeply-placed implant in a harder impression material can be compared to the firmness of a shallowly placed implant in a softer impression material. When the implant analog was placed 5 mm below the surface and its impression was made with Futar D, the force necessary to move the coping was higher than all other impression material groups, including the open tray impression coping fully embedded in an impression material. This indicates that the use of a harder occlusal registration material can compensate for an implant depth of even 5 mm.

However, transferring the in vitro technique to in vivo runs a possible risk of locking an impression intraorally when a rigid occlusal registration material engages the natural undercuts of proximal teeth. Therefore, it is necessary to be careful to syringe an occlusal registration material only around the impression coping. Only a VPS impression material should be syringed around the teeth adjacent to an implant, as an occlusion registration material is too stiff to make impressions of natural teeth and aggravates the removal of the impression from the undercuts. Occlusal registration materials and VPS impression materials are addition silicone-based materials and polymerize with each other to form a 1-piece impression.[10] The availability of occlusal registration materials with a long setting time such as Futar D Slow (Hereaus Kulzer) allows for more uniform setting of all the materials used for impression making. In addition, it should be noted that this specific usage of occlusal registration materials is suitable only for implants and should not be used to make impressions of teeth.

The results of the current study disagree with the findings of Wee,[5] who tested the torque resistance of impression materials. The rigidity of impression materials was measured by evaluating the amount of torque required to rotate the coping in the polymerized impression. The study showed that polyether produced the highest overall torque values, followed by addition silicone, then polysulfide. It was suggested that because of greater torque values, polyether and addition silicone may be favorable for the direct impression technique, as an impression material must be rigid enough to hold an impression coping and prevent its displacement when an implant analog is connected.

The results of the present study showed that there were no statistically significant differences between the heavy polyether and the extra light VPS material in each depth group. The VPS materials of lower viscosity (light body, medium, and putty) provided more stability for the impression coping than both the polyethers. These differences from the findings of Wee[5] could be explained by the different study design and the different impression materials used. The polyethers used in the Wee study were much harder than those in the present study. Moreover, the light polyether group demonstrated the lowest force values in this study. This can be explained by the Carlo et al[11] study, revealing that polyether materials had fewer inorganic particles than VPS materials. The results of the present study are also in accordance with Lu et al,[12] who found that the new polyethers were softer than addition silicone impression materials. This was contrary to the conventional belief that polyether is the stiffest elastomeric impression material. The authors also suggested that the selection of an impression material should be based on property data rather than on the type and class of the elastomeric impression material.[12]

The second null hypothesis, stating that no significant differences existed in the stability of the open tray impression coping among the groups with different implant placement depths, was also rejected. As the implant placement depth increased, the force needed to move the open tray impression coping decreased with each tested material. 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. The stability of an open tray impression coping could be reduced by using a more rigid occlusal registration material. As a result, the open tray impression coping becomes more resistant to dislodgement when the impression is removed from the mouth, the implant analog is secured, and the cast poured. The data of the present study coincide with the results of Lee et al,[6] which revealed that an increased implant depth had a negative effect on the accuracy of impressions made with a polyether medium body material. Lee et al[6] also found that when the impression coping connected to an implant submerged 4 mm subgingivally was extended by 4 mm, the distortion was not significantly different from that of implants placed at the gingival surface. It was also hypothesized that extending the impression coping provides additional retention and resistance to displacement.[6] The results of the current study indicate that a similar effect could be attained by placing an occlusal registration material around open tray impression copings of normal length. Also, this method may be less expensive (there is no need to buy specific longer impression copings, therefore copings of usual length could be reused) and could be applied to all implant systems.

However, before final conclusions can be drawn, further investigations are needed to assess whether the use of occlusal registration materials around copings reduces the overall accuracy of implant impressions.

CONCLUSIONS

Within the limits of the present study, the following conclusions were drawn:

1. 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 (*P*<.05).

2. The lower the viscosity of the VPS and polyether impression material, the less stable was the coping in the set impression.

3. In all depth groups, the coping was significantly most stable when an occlusal registration material (Futar D) was used to make impressions (*P* <.05).

4. The selection of an impression material should be based on property data rather than on the type and class of the elastomeric impression material.

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