Original Study

EFFECT OF COPING DESIGN, SUBGINGIVAL DEPTH, AND IMPRESSION MATERIAL ON THE TORQUE RESISTANCE OF IMPRESSION MATERIALS

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ABSTRACT

Aim: To evaluate the effect of coping design, subgingival depth, and type of impression material on the torque resistance of the impression in open-tray technique.

Materials & Method: Impression copings (medium length) of Straumman bone-level and tissue-level, DIO bone-level and tissue-level, Biohorizon bone-level, and Dentis bone-level systems were mounted completely perpendicular in acrylic block. To simulate subgingival depth, different thicknesses of wax were added to have 0 mm (D1), 2 mm (D2), and 4 mm (D3) in the tissue-levels or 2 mm (D1), 4 mm (D2), and 6 mm (D3) subgingival depths in bone-level systems. Open-tray technique using three impression materials including polyether, monophase addition-silicon, and one-step putty/light-body addition-silicone was used. The torque resistance of impression coping inside impression material was measured using a torque meter. Total of 432 (8 samples per group) impressions were tested. Data were analyzed with three-way ANOVA test with the significance level set at <0.05.

Results: A significant difference in the torque resistance values was found according to the type of implant system, impression material, or subgingival depth ($p < 0.05$). Torque resistance significantly decreased with the increase in the subgingival depth ($p < 0.05$). The monophase and one-step putty/light-body addition silicone had no significant difference while polyether had significantly higher torque resistance ($p < 0.05$).

Conclusion: Torque resistance of the impression is dependent on the coping design with more retentive designs having higher torque resistance. Decrease in torque resistance with higher subgingival depths could be compensated with type of the impression material.

Key words: Torque Resistance, Impression Material, Implant System, Subgingival Depth, Impression Coping, Analogue.

Introduction

One of important aspects of successful implant prosthesis is having a passive fit. Every step of implant-supported prosthesis production may influence the fit between prosthesis and implant. Among various steps, taking impression has a crucial role in the accuracy and fit of the final prosthesis.[1-4]

Although achieving an absolute passive fit prosthesis could be impossible, various factors has been detected to influence the accuracy of the impression including type of impression material, impression technique (open vs. close tray), subgingival depth, and coping design.[5,6]

Although the effect of impression material and coping design on the accuracy of the final prosthesis is relatively well established, the effect of coping design has been investigated by limited number of authors.[7-12] Rashidan *et al.*[13] found copings with less retentive shapes resulted in higher accuracy of the impression than more retentive shapes of coping. Del'Acqua *et al.*[14] evaluated the accuracy of a conventional square coping in comparison to the modified square coping. They added 2 mm extension to all sides of the coping to increase the retention. They found a significant increase in the accuracy of the final impression by enhancing the retention of the coping.

To the authors' knowledge, there is no published study evaluating the effect of the impression material and subgingival depth along with the design of impression coping on the rotational resistance of the impression. Hence the aim of the present study was to evaluate the effect of coping design, subgingival depth, and type of impression material on the torque resistance of impression. Our null hypotheses were as follow:

1) There is no significant difference in the torque resistance of different implant systems;
2) There is no significant difference in the torque resistance of different impression materials;
3) There is no significant difference in the torque resistance of different subgingival depths;
4) There is no significant interference between study variables regarding the torque resistance value.

Materials & Method

Study Design

To address the research purpose, we designed and implemented an in vitro study on various types of implant systems. Different implant systems including Straumman (Institut Straumann AG, Basel, Switzerland), DIO (DIO implant, Busan, Republic of Korea), Biohorizon (Biohorizons Implant Systems, Birmingham, AL, North America), and Dentis (Dentis Co, South Korea) were used to evaluate the effect of coping design in addition to different subgingival depths and types of impression material on the torque resistance of final impression.

Study Sample

In the present study, different impression copings (medium length) of Straumman bone level, Straumman tissue level, DIO bone level, DIO tissue level, Biohorizon, and Dentis bone level systems were tested (Figure 1a). The analogs were mounted completely perpendicular (using surveyor) in acrylic block to the level of the acrylic surface.

Figure 1: (a) implant systems investigated in the present study. (b) the analog mounted in acrylic block to the level of the acrylic surface; note that the subgingival depth was stimulated by adding different thicknesses of wax. (c) custom made trays for each subgingival depth (D1, D2, and D3) to equalize the thickness of impression material in all subgingival depths.

In order to stimulate subgingival depth, different thicknesses of wax layers were inserted on the blocks; in the tissue level systems 0 mm (D1), 2 mm (D2), and 4 mm (D3) thicknesses of wax were inserted to stimulate the corresponding subgingival depth while in bone level systems the thickness of the wax layer for subgingival depth of D1, D2, and D3 was 2, 4, and 6 mm, respectively.

Figure 2: Torque resistance of different implant systems in each subgingival depths using (a) polyether, (b) monophase, and (c) one-step putty/light-body addition silicone.

As the thickness of impression material increases with the increase in subgingival depth, custom trays were fabricated for each subgingival depth to equalize the thickness of impression material in all specimens.

Figure 3: Torque resistance of each implant system in different subgingival depths using (a) polyether, (b) monophase, and (c) one-step putty/light-body addition silicone

Open tray technique was used to take impressions using three different impression materials including regular polyether (Panasil, Kettenbach GmbH & Co, Germany), monophase addition silicon (Panasil, Kettenbach GmbH & Co, Germany), and one-step putty/light-body addition silicone (Panasil, Kettenbach GmbH & Co, German). When using the one-step putty/light-body addition silicone, putty was injected into the custom tray and the light-body injected around the impression coping.

Study Variables

The predictor variables were the coping design (different systems including Straumman bone and tissue level, DIO bone and tissue level, Biohorizon, and Dentis bone level systems), subgingival depth (D1, D2, and D3), and type of the impression material (polyether, monophase addition silicon, one-step putty/light-body addition silicone.

The outcome variable was the torque resistance of the impression copings inside the impression material measured by a torque meter.

Data Collection

Each impression was taken eight times for each implant system, subgingival depth, and impression material. Hence 72 impressions were obtained for each implant system and total of 432 impressions were collected in this study. Torque resistance of each impression coping inside impression material measured using torque meter (Mark 10, USA). Single operator measured the maximum torque resistance of each impression by trying to turn the analog which was connected to impression coping inside the impression while the tray was fixed firmly.

Statistical Analysis

Appropriate descriptive statistics including mean and standard deviation were determined for each variable. Data analysis was performed using three-way ANOVA test with SPSS 24 (IBM SPSS Statistics, Armonk, NY) software. The confidence interval was set at 95%.

Results

In the present study 432 impressions obtained from six implant systems, in three subgingival depths, and using three different impression materials. The mean torque resistance of each group is summarized. The changes in torque resistance values with different variables has been shown in Figures 2 and 3. Results of Three-way ANOVA test revealed a significant difference in the torque resistance values according to the type of implant system, impression material, or subgingival depth. Moreover, a significant interaction was found between variables. According to the Tukey post-hoc test, a significant difference was found between all implant systems except for Straumman tissue and bone level, Dentis bone level and DIO tissue level, Dentis bone level and Biohorizon bone level; all impression materials except for monophase and One-step putty/light-body addition silicone; and all three subgingival depths.

Discussion & Conclusion

The aim of the present study was to evaluate the effect of coping design, subgingival depth, and type of impression material on the torque resistance of the impression copings in the impression material. Based on the results of the study, all null hypotheses were rejected as a significant association was observed between the torque resistance and coping design, subgingival depth, and type of impression material. Moreover, significant interference was found between study variable.

In the present study, the torque resistance of polyether impression material was significantly higher than monophase addition silicon or one-step putty/light-body addition silicon. In accordance with our findings, Wee [15] observed that torque resistance of the impressions using polyether was higher than addition silicon impressions. In addition, Auroy *et al.*[16] reported that when impression bonded with adhesive to the tray, polyether had significantly higher breakdown threshold than addition silicone while the impression coping was twisted inside the impression material. However, Lee *et al.*[17] reported that most of the published studies indicate no difference between the accuracy of polyether and addition silicone. It should be noted that few studies have evaluated the torque resistance of impression and most of the articles they reviewed were evaluating the dimensional accuracy of the impression. The higher rigidity of the polyether impression material could contribute to its higher torque resistance when compared with addition silicon.[18]

Based on our findings, the design of the impression coping had significant effect on the torque resistance of impression. The retention of the impression coping in the open technique is a crucial factor in the accuracy of the final impression. In addition, the coping should be sufficiently embedded in the impression to inhibit any rotation during the tightening of the coping after removing the impression material.[16] In the present study, the least torque resistance was observed in the DIO bone level coping which could be explained by its design with only one horizontal landing. However, highest torque resistance was observed in the Straumman bone level system with two square landings, Straumman tissue level system with two triangular landings, and Dentis bone level system with three triangular horizontal landings. This correlation indicates the effect of the coping design on the torque resistance of the final impression. In accordance with the present findings Del'Acqua *et al.*[14] found that increased coping retention by adding acrylic extensions led to significant increase in the accuracy of final impression by limiting coping displacement during abutment analog tightening. In contrast, Rashidan *et al.*[13] reported that the accuracy of the final impression decreased in more retentive coping designs.

Although DIO impression coping design had a significantly lower torque resistance, using polyether as impression material improved the torque resistance values to the same of other implant systems. Hence the effect of the coping design on the torque resistance of the impression could be compensated by the type of impression material used. Polyether increased the resistance values in comparison to addition silicone except for the Dentis bone level system in which the resistance of the impression was higher in both types of addition silicones when compared to the polyether. In accordance with our findings, Moreira *et al.*[18] following reviewing 32 articles concluded that regardless of impression technique, polyether resulted in more accurate impressions in comparison to the addition silicon.

It has been reported that the accuracy of the impression decreases as the subgingival depth increases.[8,19,20] In accordance with previous findings, in the present study the torque resistance of the impression decreased significantly with the increase in the subgingival depth. However, the highest amount of decrease in the torque resistance in deeper subgingival measurements was observed in the Polyether impressions. Lee *et al.*[19] found similar results indicating that increase in the subgingival depth decreased the accuracy of polyether impression significantly while having no effect on addition silicone impressions.

In the current study addition silicones used as either monophasic with one viscosity or as one-step putty/light-body addition silicone with two viscosities. We found no statistically significant difference between two impression materials viscosity regarding the torque resistance values. This finding showed that the viscosity of the addition silicone had no effect on the torque resistance of the final impression. In contrast with the present findings, Linkevicius *et al.*[8] reported significant association between the viscosity of vinyl polysiloxane or polyether and the accuracy of the impression. This difference could be contributed to the variation in the variable measured in two studies as they measured the horizontally force needed to move the impression coping to record the stability of impression.

Prefabricated trays lead to variation in the thickness of the impression in different sites.[21] Using custom tray enable the operator to obtain equal thickness of impression material in different sites and increase the accuracy of the impression with unifying the shrinkage of the impression material in all sites of the impression.[22-24] Thus, in this study custom trays were fabricated. In addition, the thickness of the impression material was adjusted in accordance with the subgingival depth to eliminate the amount of impression material inside the tray as a confounding factor interfering with the torque resistance of the impression in three tested subgingival depths.

Impression technique can affect the accuracy of final impression; Carr,[2] Walker *et al.*,[11] Bambini *et al.*,[25] and Mostafa *et al.*[10] found that the open tray technique had higher accuracy in comparison to the closed tray technique. In the present study, all impressions were obtained using the open tray technique to eliminate the impression technique as a confounding variable.

One of the limitations in this study was using an operator to turn the coping inside the impressions. Although having a single operator could limit the variations in hand force, it remained a possible source of error in the study results. Meanwhile, in the clinical situations the impression coping would be screwed by the operator's hand and the present study design may reproduce it closely.

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