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A Comparative Study of the Accuracy between Plastic and Metal Impression Transfer Copings for Implant Restorations

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Abstract

Purpose: A precise transfer of the position and orientation of the antirotational mechanism of an implant to the working cast is particularly important to achieve optimal fit of the final restoration. This study evaluated and compared the accuracy of metal and plastic impression copings for use in a full-arch mandibular edentulous simulation with four implants.
Materials and Methods: Metal and plastic impression transfer copings for two implant systems, Nobel Biocare™ Replace and Straumann SynOcta®, were assessed on a laboratory model to simulate clinical practice. The accuracy of producing stone casts using these plastic and metal impression transfer copings was measured against a standard prosthetic framework consisting of a cast gold bar. A total of 20 casts from the four combinations were obtained. The fit of the framework on the cast was tested by a noncontact surface profilometer, the Proscan 3D 2000 A, using the one-screw test. The effects of implant/system and impression/coping material on gap measurements were analyzed using repeated measures ANOVA.
Results: The findings of this in vitro study were as follows: plastic copings demonstrated significantly larger average gaps than metal for Straumann ($p = 0.001$). Plastic and metal copings were not significantly different for Nobel ($p = 0.302$). Nobel had significantly larger average gaps than Straumann for metal copings ($p = 0.003$). Nobel had marginally smaller average gaps than Straumann ($p = 0.096$) for plastic copings. The system-by-screw location interaction was significant as well ($p < 0.001$), indicating significant differences among the four screw locations, but the location differences were not the same for the two systems. A rank transformation of the data was necessary due to the nonnormal distribution of the gap measurements. No adjustments were made for multiple comparisons.
Conclusions: The metal impression copings were more accurate than plastic copings when using the Straumann system, and there was no difference between metal and plastic copings for the Nobel Replace system. The system-by-screw location was not conclusive, showing no correlation within each system

An impression that records the antirotational mechanism of the implant must be accurate and reproducible, so that the resultant master cast precisely duplicates the clinical condition. This cast obtained from the implant fixture impression must also reproduce the adjacent hard and soft tissues accurately. Hence, the accuracy of the cast is dependent on the impression procedure and the implant master cast technique. The fabrication of master casts for conventional crowns and fixed partial dentures (FPDs) has been well reported.[1-5] Studies on the materials used in master cast fabrication have reported acceptable accuracy for clinical use in crowns and FPDs, but to date no studies have demonstrated that master casts accurately reproduce the dimensions of the oral cavity.[1-5] However, the periodontium can allow for adjustments of minor distortions, especially in FPDs, and the cement will fill in the residual gaps between the casting and the abutment tooth. According to Rudd et al[6] and Assif et al[7] a dental implant has extremely limited movement, approximately 10 μm. This lack of implant flexure means that any tensile, compressive, and bending forces introduced into an implant-supported restoration due to misfit will certainly remain there. Given that these forces have not been relieved, a series of problems ranging from screw loosening to loss of osseointegration have been reported to occur.[8-12]

Daoudi et al[13] investigated the accuracy of the pick-up impression method at the abutment level and the repositioning method at the implant level using two elastomeric materials: poly(vinyl siloxane) (PVS) and polyether. They concluded that the repositioning technique at the implant level can produce less predictable results than the pick-up technique at the abutment level. No significant differences were established regarding the choice of impression material.

Daoudi et al[14] also studied the accuracy of the repositioning impression technique at the implant level using PVS impression material. The authors concluded that the use of an implant level impression technique can be clinically unpredictable and may necessitate adjusting or even remaking the final restoration.

In another study, Daoudi et al looked at three implant level impression techniques using PVS impression material. The tested techniques were: (1) the repositioning technique, (2) the pick-up technique, and (3) the pick-up technique with the impression coping splinted to the impression tray with autopolymerizing acrylic resin. The results showed significant differences in implant-analog position with the repositioning and pick-up (unsplinted) impression techniques from the master model. Significant rotational errors were recorded with the repositioning and pick-up (unsplinted) techniques; however, connecting the impression coping to the impression tray improved the accuracy of the pick-up impression technique.[15]

Vigolo et al[16] evaluated the accuracy of the master cast made using square pick-up impression copings for single-tooth replacement. Copings used were: (1) copings as sold by the manufacturer, and (2) copings modified by sandblasting and coated with impression adhesive before the final impression procedure. The results showed that the rotational position changes of the hexagon on implant replicas were significantly less variable in the master cast obtained with the modified impression copings than in the master cast achieved with the unprepared copings. The copings were either used as sold by the manufacturer or modified by sandblasting and coated with impression adhesive before the final impression procedure.

Vigolo et al[17] compared the accuracy of a master cast obtained using copings modified by sandblasting and coated with impression adhesive before the final impression procedure to ones obtained using gold, machined UCLA abutments, as impression copings in the final impression procedure for single-tooth, implant-replacement cases. The results showed that the rotational position of the hexagon on implant replicas is significantly less variable in the master cast obtained using gold, machined UCLA abutments as impression copings than in the master casts achieved with the roughened square impression copings. Thus, this report suggested that using gold, machined UCLA abutments as impression copings in the final impression procedures enables clinicians to achieve a more accurate orientation of implant replicas in laboratory master casts for single-tooth, implant-replacement cases.

Kivanc and Murat[18] compared the accuracy of casts produced by direct and indirect level impression techniques. They found that using the snap-on PVS indirect impression technique using the stock tray resulted in dimensional accuracy similar to that achieved with the polyether direct technique.

Although a number of reports evaluated implant impression techniques in general, little work has been done to compare and investigate the accuracy of these implant impression techniques, and even less can be found in the literature regarding the accuracy of the snap-on impression techniques. Prosthodontic components for implant treatment have evolved on the basis of individual experiences and professional opinions, with minimal evidence of published prospective laboratory or clinical testing.

Therefore, the purpose of this study was to compare the accuracy between casts created by plastic impression copings and the casts produced using metal impression transfer copings with an implant level technique.

Hypothesis: The null hypothesis, H_0, was that no dimensional difference will result between the casts fabricated from the plastic impression copings and the casts produced from the metal impression copings. The first alternative hypothesis, H_{A1}, was that the casts fabricated from the plastic impression copings are less accurate than the casts made from the metal impression transfer copings. The second alternative hypothesis, H_{A2}, was that the casts made from the plastic impression copings are more accurate than the casts prepared from the metal impression copings.

Materials and methods

In this in vitro study, a mandibular aluminum model (No. 641, Columbia Dentoform Comp., New York, NY) was used. Four holes were prepared in the aluminum model to receive the titanium fixtures. The four holes were used to embed each of the four Nobel Replace System fixtures (32217, Lot 667937, Nobel Biocare AB Goteborg, Sweden). Four Straumann SynOcta Ti fixtures (043.252S4, Straumann SynOcta, Basel, Switzerland) were placed in the aluminum model after removal of the Nobel Replace fixtures once data collection was finished. The distance between each implant hole was approximately 8 mm center to center, and each hole was 9 mm in depth.

Figure 1 Cast gold bar on Nobel Biocare master cast.

Figure 2 Cast gold bar on Straumann master cast.

Two cast bars, one for each system tested, were used as a standard reference throughout this study. For the Nobel Replace Implant System, the cast bar was fabricated with four Gold Adapt nonengaging abutments (29011, Lot 87437 Nobel Biocare AB) tightened down to the Ti fixtures using abutment screws (Fig 1). Then, each implant/abutment unit was placed into a prepared hole, and plastic bars (99–560000, Attachment International, Inc. San Mateo, CA) and GC pattern resin (GC America, Alsip, IL) were used to connect the four abutments forming a pattern for the cast bar. This plastic pattern was sprued and invested, and after burnout, was cast with Type IV gold alloy (Harmony Williams Gold Refining Co., Buffalo, NY).

The coping screw for each implant/abutment group was assigned a number 1 through 4 relative to the implant fixture position from left to right. Each coping screw was attached with the cast bar to each corresponding implant fixture using the Nobel Replace torque wrench to a torque of 15 Ncm. The fixtures were then embedded into the mandibular aluminum model with epoxy resin (Loctite Weld, Loctite, Cleveland, OH), and the resin was allowed to set for 24 hours. The result was a mandibular aluminum model with a passive standard fixed implant framework fitted to it.

For the Straumann SynOcta Implant System, the cast bar was fabricated inserting four abutments (048.602, Straumann SynOcta) into the four octagon fixtures and securing the implant/abutment units with a transocclusal screw tightened with a 15 Ncm torque according to the manufacturer's recommendation (Fig 2). To get the 15 Ncm in each implant/abutment unit, a screwdriver attached to a ratchet head was used.

Four gold copings without an internal octagon (048.63, Straumann SynOcta) for FPD fabrication were positioned over the abutments, and guide screws (048.350V4, Straumann SynOcta) were used to secure them. Then, each unit of implant/abutment/gold coping was placed into a prepared hole, and plastic bars and GC pattern resin were used to connect the four gold copings to form a pattern for the cast bar. This plastic pattern was sprued and invested, and after burnout, was cast with Harmony Type IV gold alloy. The implants were attached to the bar and embedded in the aluminum cast as described earlier.

Each aluminum model with embedded Ti fixtures was used as a master cast to make impressions for each of the implant system combinations. For the Straumann SynOcta system, a custom tray was fabricated in two designs: open and closed. Light-polymerized resin (Triad, Dentsply, York, PA) was used to make the custom trays. To control the volume of impression material underneath the custom tray and around the implant, a silicone mold was fabricated for each design. Three location stops were used as follows: the left retromolar pad, the right retromolar pad, and the lingual area of the anterior region to ensure that 2.0- to 2.5-mm spacing was created for each tray. For the Nobel Replace system, a custom tray was fabricated in a closed design when using metal impression copings as well as when using plastic impression copings. The same procedures were followed throughout the fabrication of both custom trays, and the same material was used (Triad) to make these custom trays.

Aquasil Ultra Monophase (678773; Lot 061107 Dentsply Caulk Milford, DE; ISO 4823), a hydrophilic addition reaction silicone, Type 2, medium-bodied consistency, regular set impression material was used. Automixing guns were used to mix and dispense impression material. All impressions were made from the implant master model for each implant system and for each metal and plastic snap-on transfer impression coping system. The manufacturer's suggested setting time of 5 minutes was doubled to compensate for polymerizing at room temperature rather than mouth temperature.[19] A digital timer was used to standardize each step of the procedures.

The impression technique for the Nobel Replace system with the metal impression copings and implant-level closed-tray procedure used four metal impression copings (33540 Nobel Biocare), one connected to each of the implant fixtures. Each of these impression copings was secured with a screw hand tightened to each of the implant fixtures according to manufacturer's recommendations. Block-out of the guide pin holes with wax was necessary to allow for their removal. The custom tray without perforations was painted with tray adhesive Caulk (626155 Dentsply Caulk), and addition silicone was dispensed into the tray and around each impression coping connected to each of the implant fixtures. The loaded tray was positioned in place once the addition silicone was set. Then, the impression was removed without the impression copings. The four impression copings were removed from the four implant fixtures after screw loosening, and then they were threaded onto the corresponding implant replica (29500 Nobel Biocare). Each implant replica assembly was replaced into its corresponding location in the impression, and a master cast was fabricated with type IV stone. This procedure was repeated five times.[19]

The impression technique for the Nobel Replace system using the plastic snap-on impression copings (32426 Nobel Biocare) and implant-level closed-tray procedure used four impression copings coupled to each of the implant fixtures without using screws. Each coping snapped as it slid through the tri-channel internal connection of each implant fixture. Once in place, addition silicone within the closed custom tray was used to make the impressions. The custom tray without perforations was painted with tray adhesive, and addition silicone was dispensed into the tray and around each impression coping connected to each of the implant fixtures. The loaded tray was positioned in place, and the impression was removed once the addition silicone was set. The impression was removed with the four plastic snap-on impression copings in it. The master cast was then fabricated. In this technique, analogs (29500 Nobel Biocare) were fixed on each of the four plastic snap-on impression copings. Each analog was positioned as it slid through the trichannel connection of each plastic impression coping. Stone was poured into the impression to fabricate the master cast. This procedure was repeated five times.[19]

The impression technique for the Straumann SynOcta system using the metal impression copings (048.090 Straumann) and implant-level, open-tray procedure used one metal impression coping connected to each of the four implant fixtures. Each impression cap was pushed onto the implant and hand-tightened with the integral screw. The custom tray containing the perforations for the guide screws was painted with tray adhesive, and addition silicone was dispensed into the tray and around each impression coping. The loaded tray was positioned in place, and once the addition silicone was set, the four guide screws were loosened, and the impression was removed. The master cast was then fabricated. In this technique, analogs (048.124 Straumann) were fixed on each of the four metal impression copings using the integral guide screws, and the stone was poured to fabricate the master cast. This procedure was repeated five times.[19]

The impression technique for the Straumann SynOcta system using the snap-on impression copings and implant-level closed-tray procedure used four plastic impression caps (048.017V4 Straumann) and four positioning cylinders (048.070V4 Straumann). Each impression cap was pushed onto the implant shoulder until it clicked into place. To check that the cap was in the correct position, it was rotated on the implant. The second component, the positioning cylinder, was then inserted. The octagon of the positioning cylinder was properly aligned with the octagon in the implant and pushed into the impression cap until it met the flat part of the impression cap. The custom tray without perforations was painted with tray adhesive, and addition silicone was dispensed into the tray and around the impression copings connected to each of the implant fixtures. The loaded tray was positioned in place, and once the addition silicone was set, the impression was removed. This impression had the snap-on impression copings retained in it. The master cast was then fabricated. In this technique, analogs (048.124; Straumann) were fixed on each of the four plastic snap-on impression copings. The analogs were positioned into the impression cap shoulder with an audible click. Stone was poured into the impression to fabricate the master cast. This procedure was repeated five times.[19]

Figure 3 Proscan profilometer.

ResinRock (Whip Mix Corp, Louisville, KY) was used to make the stone master casts. The addition silicone impression was poured immediately after removal from the aluminum master cast according to the manufacturer's recommendation. The Type IV stone, ResinRock, was vacuum-mixed with distilled water according to manufacturer's recommendations. The water-to-powder ratio is 23 ml of distilled water per every 100 g of ResinRock stone. A total of 20 casts from the four combinations were obtained. Each cast was allowed to set for 1 hour before unscrewing the guide pins or removing the snap-on impressions.

The recordings for this project were made using a noncontact surface profilometer, the Proscan 3D 2000 A (Scantron Industrial Products, Somerset, UK) (Fig 3). The Proscan 3D 2000 transmits safe white light through a lens with a carefully designed spectral aberration built into it. This effect takes the white light and divides it into the full spectral field, focusing each color frequency at a slightly different point through a defined measuring range. When an object is placed within this range, only one color frequency reflects back from the surface. This information is then passed to a processor where a spectrometer analyzes the signal and converts it to a measurement. The Proscan combines these measurements with the precise location of a moving X/Y linear table to create three coordinates from which to create a 3D profile. The sensor may have up to 0.01-μm resolution.[20] The chromatic sensor used in this study is the S 65/10 with a resolution of 0.3 μm and a linearity of range within $\pm 0.1\%$. The measuring range of this sensor is 10 mm, and the standoff is 65 mm.

A holding device (Fig 4) was designed and fabricated to position the implant/abutment interface for profilometer scanning and reading in a standardized and repeatable manner. The holding device had a spinning vertical table with four marks corresponding to each implant/abutment crossing point to be scanned. One side of the table had three pins that engaged each cast (master and experimental) using three reference points created in the master cast and then transferred to the experimental casts within the impression procedure. The other side of the

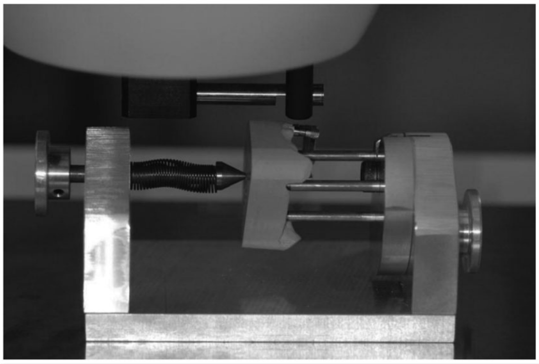

Figure 4 Holding device positioned in profilometer for scanning.

table had a spring-loaded plunger that permitted placement and secured the casts into each reading position.

As previously disclosed, two cast bars, one for each system tested, were used as a standard reference throughout the experiment. The standard Nobel Replace gold cast bar was used as the reference for measurement of the gap between the standard cast bar and abutment analogs on the five experimental casts fabricated while using metal impression copings. The hexed coping screw for position 1 for the Nobel Replace system using the metal impression copings and implant-level, closed-tray procedure was used to tighten the standard gold cast bar to implant analog position 1 on the experimental cast no. 1. A measurement was made and recorded for the implant/abutment interface at positions 1, 2, 3, and 4 within the same experimental cast no. 1. Then, the hexed coping screw for position 1 was removed, and a hexed coping screw for position 2 was tightened at position 2 of the same cast. The measurement was made in the same manner as for position 1. Each hexed coping screw for each position was used, and the measurements were made following the same method every time.

The same standard Nobel Replace gold cast bar was used as a reference for measurement of the Nobel Replace system using the plastic snap-on impression copings, implant-level closed-tray procedure. The standard Nobel Replace gold cast bar was secured into position, and gap measurements between the standard cast bar and abutment analogs of the five experimental casts were recorded (Fig 5). The hexed coping screw for position 1 was used to tighten the standard gold cast bar to implant analog position 1 on experimental cast no. 1. Each hexed coping screw for each position was used, and the measurements were obtained with the same method used in the previous metal impression copings (Fig 6).

For the Straumann SynOcta system, the measurements were performed at the implant/abutment/gold coping interface of the standard cast bar for both the metal impression copings and the snap-on impression copings techniques (Fig 7). The procedures were done in the same fashion for the ten experimental casts. Five experimental casts from the metal impression coping technique and five more from the snap-on impression coping technique were measured. For the metal impression copings, the occlusal screw for position 1 was used to secure the standard gold cast bar to the abutment/gold coping at position 1 on experimental cast no. 1. The measurement was made and recorded for the abutment/gold coping interface of positions 1, 2, 3, and 4. Then the occlusal screw for position 1 was removed, and the occlusal screw for position 2 was used to secure the bar at position 2. The measurement was made in the same way as for the occlusal screw at position 1. Each occlusal screw for each position was used, and the measurements were obtained in the same manner every time (Fig 8).

For the snap-on impression copings technique, the Straumann SynOcta gold cast bar was used as a reference for measurements of the gap between the standard cast bar and the abutment/gold coping interface of the five experimental casts. The occlusal screw for position 1 was used to tighten the standard gold cast bar to the implant analog gold-coping position 1 on experimental cast no. 1. Each occlusal screw for each position was used to secure the reference cast bar, and the measurements were obtained in the same fashion as previously described.

Statistical methodology

The effects of implant/system and impression/coping material on gap measurements were analyzed using repeated measures ANOVA. The repeated measures model was necessary to correlate multiple observations within a cast from two materials for four screw positions when each screw position was individually tightened. The primary comparison was between plastic and metal impression copings. Secondary comparisons were between the two implant systems and among the four screw locations. A rank transformation of the data was necessary due to the nonnormal distribution of the gap measurements. No adjustments were made for multiple comparisons.

Results

Each of the two implant systems (Straumann SynOcta and Nobel Replace) used one mandibular aluminum model. A cast bar was used as a standard reference for each system. The gap was measured at each of four implant positions as the screw location was rotated among the four positions. Each gap was measured three times, and the average of the three measurements was used in the analyses. Summary statistics regarding these master casts are presented in Tables 1 to 3. Metal and plastic impression transfer copings were then used with each system. Five casts were made using each coping material. The gaps were measured as described above (Table 2), and the master cast gaps were subtracted (Table 3).

The system/material interaction was significant ($p = 0.003$), so that material comparisons must be interpreted separately for each system. The system comparisons also must be interpreted separately for each material. Plastic had significantly larger average gaps than metal for Straumann ($p = 0.001$), but for Nobel, plastic and metal were not significantly different ($p = 0.302$) (Fig 9). Nobel had significantly larger average gaps than Straumann for metal ($p = 0.003$), but for plastic, Nobel had marginally smaller average gaps than Straumann ($p = 0.096$). The system/screw location interaction was significant as well ($p < 0.001$), indicating significant differences among the four screw locations, but the location differences were not the same for the two systems. With the Nobel system, position 3 had significantly smaller average gaps than positions 1 ($p = 0.007$) and position 4 ($p < 0.001$) and had marginally smaller average gaps than position 2 ($p = 0.078$), and position 2 had significantly smaller average gaps than position 4 ($p = 0.040$). With the Straumann system, position 1 had significantly smaller average gaps than position 3 ($p = 0.017$) and marginally smaller average gaps than position 2 ($p = 0.096$), and position 4 had significantly smaller average gaps than position 3 ($p = 0.029$).

Discussion

The objective of this study was to compare the accuracy between casts fabricated using plastic impression copings and casts made using metal impression transfer copings with an implant level technique. Two implant systems were tested: Straumann SynOcta and Nobel Replace. Each standard fixed/detachable implant framework (reference cast gold bar) provided the baseline distance for distortion comparison associated with the ten experimental casts within each implant system.

The accuracy of a definitive cast is crucial in the sequencing for successful implant prosthodontics. Several factors should be considered when restoring implants.

Four kinds of implant component displacements can be introduced when making a definitive cast. The first is the displacement of each impression coping on the mating surface of each implant within the range of machining tolerance. Ma et al[21] defined machining tolerance as "the difference in rest position between the components when these components are held in place by their respective fastening screws."

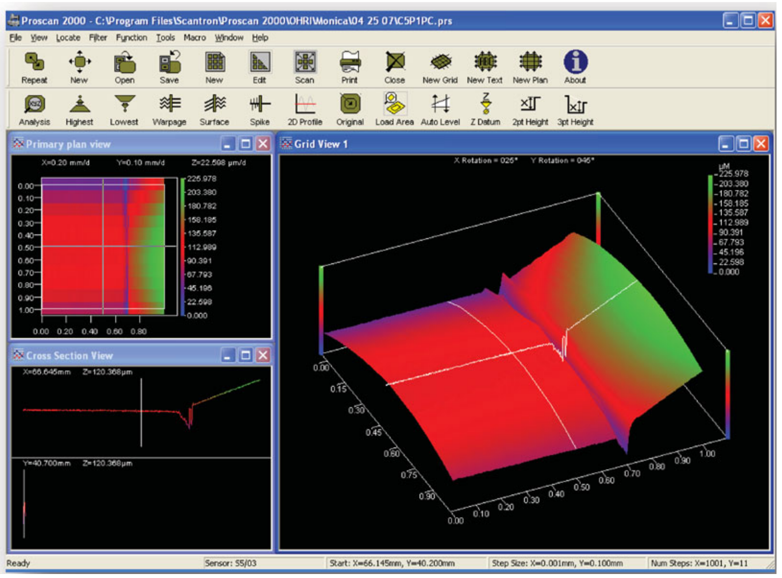

Figure 5 Example of scanned duplicate cast when using Nobel plastic copings.

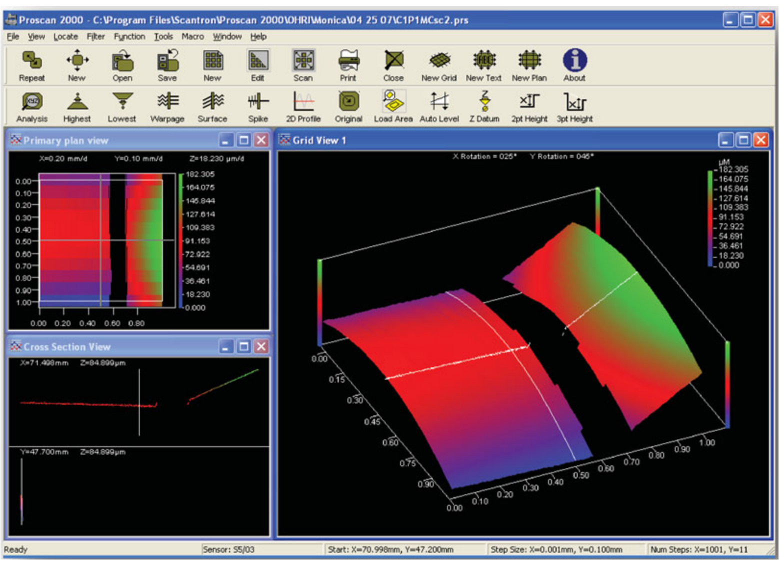

Figure 6 Example of scanned duplicate cast when using Nobel metal copings.

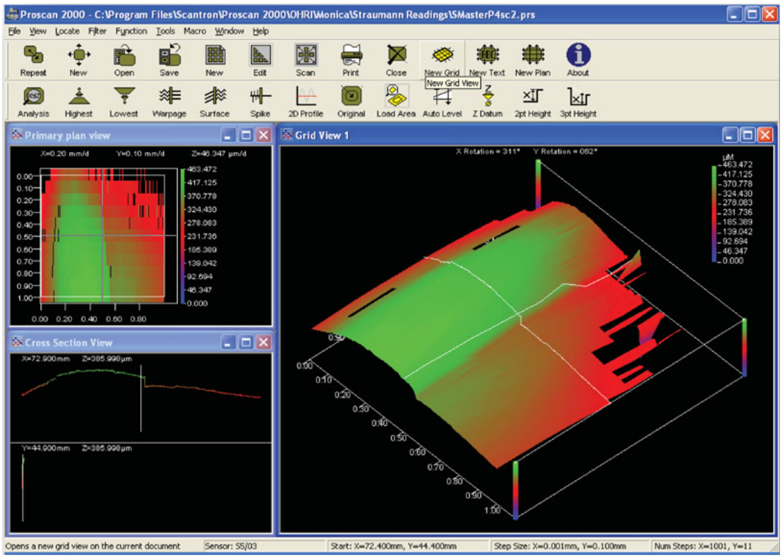

Figure 7 Example of scanned duplicate cast when using Straumann plastic copings.

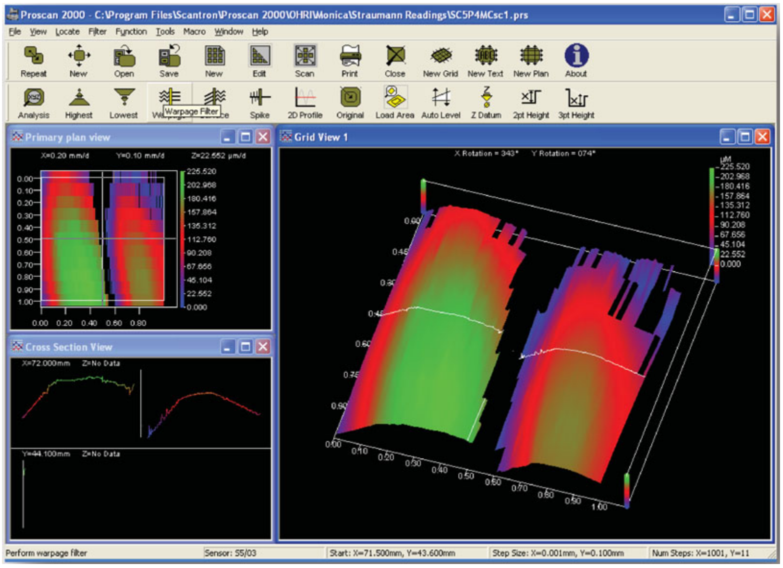

Figure 8 Example of scanned duplicate cast when using Straumann metal copings.

Furthermore, they concluded that the machining tolerance between Brånemark standard abutment components ranged from 22 to 100 μm. Binon[22] reported that the amount of rotational freedom between a Brånemark 3.75-mm-diameter implant and a standard abutment was 6.7°, and the average flat-to-flat width was 2.707 mm.

The second factor is the displacement of each impression coping resulting from the impression technique. Numerous studies investigating the accuracy of implant impressions have been published.[7,13-15,18-19,23,24] These studies have described various methods to assess the amount of distortion. Microscopes have been used to compare a reference distance in the patient and in the definitive cast. Strain gauges have been used to evaluate the frequency values produced in a metal framework on the patient and on the definitive cast. The impression technique used in our in vitro study was the implant-level, closed-tray technique for the plastic and metal impression transfers within the Nobel Replace implant system. For the Straumann Syn-Octa system, an implant-level closed tray was also used with the plastic snap-on impression transfers; however, for the metal impression copings, an implant-level open-tray technique was used due to the lack of metal impression copings for a closed-tray technique within this system. This may be a point to consider when comparing among the metal impression transfers between both implant systems.

The third factor is the type of impression material used. Many studies have also evaluated the dimensional accuracy of impression materials.[25-30] These studies have described various methods to assess the amount of distortion. Addition silicone was the material selected for this study. There is ample evidence in the literature that an impression material such as addition silicone has properties ideally suited for direct-coping transfer.

Table 1 Master cast gap measurements

System	Screw position	Implant position	Gap (mm)
Nobel	1	1	0
	1	2	0
	1	3	0.023
	1	4	0
	2	1	0
	2	2	0.004
	2	3	0.016
	2	4	0.030
	3	1	0.021
	3	2	0.009
	3	3	0
	3	4	0
	4	1	0.026
	4	2	0.035
	4	3	0.009
	4	4	0
Straumann	1	1	0
	1	2	0
	1	3	0.002
	1	4	0.005
	2	1	0
	2	2	0
	2	3	0.003
	2	4	0
	3	1	0.003
	3	2	0
	3	3	0
	3	4	0.029
	4	1	0
	4	2	0.037
	4	3	0.018
	4	4	0.015

Table 2 Gap in millimeters

Material	System	N	Median	25th percentile	75th percentile	Min	Max
Metal	Nobel	80	0.056	0.005	0.108	0	0.421
	Straumann	80	0.000	0	0.009	0	1.547
Plastic	Nobel	79	0.026	0.004	0.064	0	0.707
	Straumann	80	1.241	0	2.634	0	5.769

This material may provide sufficient rigidity to prevent rotation of any component during the impression transfer or analog-fastening and cast fabrication.[31,32]

The fourth factor is the displacement of each abutment replica in the definitive cast because of the dimensional change of the dental stone. Many studies are available analyzing this issue.[1–5,16,17,31,33–35] This study used type IV dental stone. According to Anusavice,[32] type IV dental stone has a linear setting expansion of 0.10% at most. Therefore, the expansion of dental stone during setting may be able to displace impression coping/abutment replica assemblies. This point should be considered when comparing among the metal impression transfers between both implant systems.

Table 3 Gap adjusted for master cast gap (mm)

Material	System	N	Median	25th percentile	75th percentile	Min	Max
Metal	Nobel	80	0.044	0	0.092	–0.023	0.415
	Straumann	80	0.000	–0.003	0.006	–0.037	1.547
Plastic	Nobel	79	0.024	0	0.052	–0.021	0.681
	Straumann	80	1.232	0	2.632	–0.037	5.769

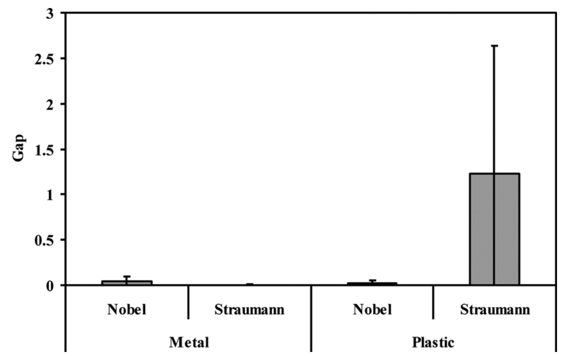

Figure 9 Gap adjusted for master cast gap. Median with bars from 25th percentile to 75th percentile.

Another factor influencing the accuracy of the definitive cast is related to the material used in the manufacturing of the impression copings. Until now, most implant accuracy studies have not tested the influence of using plastic impression copings against metal fixtures in the impression transferring procedure. This in vitro study attempted to compare the accuracy between casts fabricated using plastic impression copings and casts made using metal impression transfer copings with an implant-level technique.

The first and third types of displacement were not considered when evaluating the results, because these displacements are not related to the different impression techniques. Moreover, these displacements cannot be controlled.

The statistical analysis showed different results for each system tested. Within the Nobel Replace system, no significant difference was observed between plastic and metal impression copings. On the other hand, in the Straumann system, plastic impression copings demonstrated significantly larger average gaps than the metal. Furthermore, Figure 10 shows evidence of breakage and distortion of the white impression cap engaging the implant shoulder, potentially explaining these study findings. These results provide evidence that casts fabricated from plastic impression copings are less accurate than the casts made from metal impression transfer copings; however, the measurements within the metal impression copings demonstrated that the Nobel system had significantly larger average gaps than the Straumann system.

The lost-wax technique was used in this study to fabricate the reference cast gold bar used throughout the measurements. It is acknowledged that the accuracy of this technique depends on multiple factors, including the waxing technique, spruing method, type/method of investment, and type/manipulation of the gold alloy.[36] Therefore, to control some of these possible

Figure 10 Straumann broken plastic impression coping.

error sources, the implant fixtures were embedded in the metal mandibular cast after the casting procedure. Once the bar was finished, it was fastened with the four screws to the four implant fixtures, and epoxy resin was used to fix each position.

When screw locations were compared between the two systems, significant differences were observed. The variations at the different screw locations were not the same for the two systems tested. Within the Nobel system, position 3 had significantly smaller average gaps than positions 1 and 4, but marginally smaller than position 2. Position 2 had a significantly smaller average gap than position 4. Within the Straumann system, position 1 had significantly smaller average gaps than position 3 and marginally smaller than position 2. Position 4 had significantly smaller average gaps than position 3. These data are in contrast to data from the reports by Jemt[10] and Tan et al.[36] Their studies suggested that the one-screw test for evaluation of framework fit, especially effective for long-span frameworks, showed that vertical discrepancies tend to be magnified at the opposite terminal abutment; however, the discrepancies are often masked if the distortion occurred in the negative z-axis direction.

The most desirable clinical situation between an implant framework and the abutments is "passive fit." Results of this study indicate that plastic impression copings for multiple implant restorations in the Straumann system are significantly inaccurate. Moreover, a fracture at the edge of the plastic impression caps occurred in two specimens, one prior to making the impression, and the other after pouring the impression (Fig 10).

This study has taken a step in the direction of defining the influence of using plastic impression copings in the transfer of the exact position and orientation of the antirotation mechanism of an implant to the working cast. It is possible that other studies with a different methodology may produce entirely different results. In addition, it is important to emphasize that methodological problems in the research design limit our interpretations.

Further studies are required to fully understand the influence that plastic impression transfer copings can have on the accuracy of the working cast. Although this study indicates that plastic impression transfer copings are significantly inaccurate in the transfer of the exact position and orientation of the antirotation mechanism of an implant to the working cast, additional clinical studies would be helpful to establish the clinical relevance of this finding.

Conclusions

Plastic and metal impression transfer copings for two implant systems, Nobel Biocare™ and Straumann SynOcta®, were assessed on a laboratory model to simulate clinical practice. The accuracy of producing stone casts using these plastic and metal impression transfer copings was measured against a standard prosthetic framework (cast gold bar). The fit of the framework on the cast was tested by a noncontact surface profilometer, the Proscan 3D 2000 A using the one-screw test. The findings of this in vitro study were as follows:

(1) Plastic had significantly larger average gaps than metal for Straumann ($p = 0.001$).
(2) Plastic and metal were not significantly different for Nobel ($p = 0.302$).
(3) Nobel had significantly larger average gaps than Straumann for metal ($p = 0.003$).
(4) Nobel had marginally smaller average gaps than Straumann ($p = 0.096$) for plastic.
(5) The system-by-screw location interaction was significant as well ($p < 0.001$), indicating significant differences among the four screw locations, but the location differences were not the same for the two systems.
(6) With the Nobel system, position 3 had significantly smaller average gaps than positions 1 ($p = 0.007$) and 4 ($p < 0.001$) and had marginally smaller average gaps than position 2 ($p = 0.078$), and position 2 had significantly smaller average gaps than position 4 ($p = 0.040$).
(7) With the Straumann system, position 1 had significantly smaller average gaps than position 3 ($p = 0.017$) and marginally smaller average gaps than position 2 ($p = 0.096$), and position 4 had significantly smaller average gaps than position 3 ($p = 0.029$).

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