An evaluation of impression techniques for multiple internal connection implant prostheses

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Statement of problem. Movement of impression copings inside the impression material using an open-tray impression technique during clinical and laboratory phases may cause inaccuracy in transferring the 3-dimensional spatial orientation of implants intraorally to the definitive cast. Consequently the restoration may require corrective procedures.

Purpose. This in vitro study evaluated the accuracy of 3 different impression techniques using polyether impression material to obtain a precise definitive cast for a multi-unit implant restoration with multiple internal connection implants.

Material and methods. A reference acrylic resin model with 4 internal connection implants (3i Implant Innovations) was fabricated. Forty-five medium-consistency polyether impressions (Impregum Penta) of this model were made with square impression copings using an open-tray technique. Three groups of 15 specimens each were made with different impression techniques: in the first group, nonmodified square impression copings were used (NM group); in the second group, square impression copings were used and joined together with autopolymerizing acrylic resin before the impression procedure (R [resin] group); and in the third group, square impression copings previously airborne-particle abraded and coated with the manufacturer-recommended impression adhesive were used (M [modified] group). Matching implant replicas were screwed into the square impression copings in the impressions. Impressions were poured with ADA type IV stone (New Fujirock). A single calibrated examiner blinded to the nature of the impression technique used examined all definitive casts to evaluate the positional accuracy (μm) of the implant replica heads using a profile projector (at original magnification $\times 10$). These measurements were compared to the measurements calculated on the reference resin model which served as control. Data were analyzed with a 1-way analysis of variance at α =.05, followed by the Student Newman-Keuls test (α=.05).

Results. The data obtained with the profile projector revealed significant differences within the 3 impression techniques ($P<.001$). The Student Newman-Keuls procedure disclosed significant differences between the groups, with group R casts being significantly more accurate than group NM and group M casts (P=.05). The mean distance ($\pm$SD) between the posterior implants compared to the reference acrylic resin model was 18.17 μm ($\pm$ 6.4) greater for group R casts, 41.27 μm ($\pm$ 8.4) greater for group M casts, and 46.21 μm ($\pm$ 8.9) greater for group NM casts. Distances between the anterior implants were also greater than those recorded on the reference model. The distance was 15.23 μm ($\pm$ 5.9) greater on group R casts, 38.17 μm ($\pm$ 8.3) greater on group M casts, and 43.23 μm ($\pm$ 8.7) greater on group NM casts.

Conclusion. Within the limitations of this study, improved accuracy of the definitive cast was achieved when the square impression copings joined together with autopolymerizing acrylic resin were used to make an impression of multiple internal connection implants. (J Prosthet Dent 2004;92:470-6.)

CLINICAL IMPLICATIONS

The results of this study suggest that splinting implant impression copings with autopolymerizing resin when multiple internal connection implants are to be restored should result in more accurate definitive casts.

The connection of a fixed partial denture (FPD) to osseointegrated implants produces a unified structure in which the FPD, the implants, and the bone act as a unit.[1-3] Any misalignment of the FPD to the osseointegrated implants may induce internal stresses in the FPD, the implants, and the bone matrix.[4,5] An endosteal

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implant distributes the physiologic loads imposed on it onto the surrounding supporting tissues.[6] Implant units, unlike natural teeth cushioned in the alveoli by periodontal fibers, are somewhat intolerant of movement in their adaptation to the demands of the metal supporting structure. The slight mobility of osseointegrated implants is ascribed to the "elasticity" of the investing bone.[7]

There is a general awareness that the placement of implants and subsequent prostheses can effect changes in the metastable matrix of supporting bone.[4,5] Whether the changes will be destructive or constructive in a given situation is not entirely predictable. It has been suggested that forced tightening of the metal supporting structure can result in microfractures of bone, zones of marginal ischemia, and healing with a nonmineralized (fibrous connective tissue) attachment to the implant.[4] Others have suggested that there may be an as yet undetermined optimum, or at least adequate, stress distribution dictated by design and material that will encourage maintenance of marginal bone proximal to the implant.[8,9] There is significant uncertainty with regard to the range of stress that may be clinically tolerable with respect to the long-term retention of these devices. It is believed that a successful result can only be completely achieved through the fabrication of passively fitting prostheses.[10,11]

Several impression techniques have been advocated to achieve a definitive cast that will ensure the passive fit of a prosthesis on osseointegrated implants. To ensure maximum accuracy, Brånemark et al[1] emphasized the importance of splinting transfer copings together, intraorally, before registration of the definitive impression. The same technique has been used by others with minor modifications.[12-17] Assif et al[18] compared the accuracy of 3 implant impression techniques with the use of 3 different splinting materials. Significantly more accurate results were obtained with techniques in which autopolymerizing acrylic resin or impression plaster, rather than dual-polymerizing acrylic resin, was used as the splinting material. Humphries et al,[19] Hsu et al,[20] and Herbst et al[21] found no significant differences between the values obtained with acrylic resin-splinted versus unsplinted copings in impression techniques. Inturregui et al[22] and Burawi et al[23] reported that the splinted technique exhibited more deviation from the definitive cast than the unsplinted technique.

More complicated and time-consuming techniques to achieve passively fitting prostheses have been described by other authors for situations involving multiple implant restorations. Carr and Master[24] described a metal impression coping system, featuring a cross-wing design that was rotated into contact with an adjacent coping and connected with autopolymerizing acrylic resin. This process simulated the framework reorientation procedure and could be considered a potential substitute for the verification cast procedure in the framework fabrication process.

In a previous study, Vigolo et al[25] evaluated the accuracy of 3 different impression techniques using polyether impression material to obtain a definitive cast for the fabrication of a prosthesis that would fit passively on multiple implants. In the first group, nonmodified square impression copings were used; in the second, square impression copings were used and joined together with autopolymerizing acrylic resin before the impression procedure; and in the third, square impression copings, previously airborne-particle abraded and coated with the manufacturer-recommended impression adhesive, were used. Improved accuracy of the definitive cast was achieved when the impression technique involved square impression copings joined together with autopolymerizing acrylic resin or square impression copings that had been airborne-particle abraded and adhesive coated.

A new connection system has recently been introduced (Osseotite Certain Implant System; 3i Implant Innovations Inc, Palm Beach Gardens, Fla). This implant has a 4-mm–deep internal engagement with thick coronal walls and uses a system of engagement that confirms proper seating of different components.

The best impression technique for this type of implant has not yet been identified. The purpose of this in vitro study was to evaluate the accuracy of 3 different impression techniques using polyether impression material to obtain a definitive cast. A standardized measurement protocol was used to compare these 3 impressions.

MATERIAL AND METHODS

An acrylic resin model (Blue Star Type E; Breitschmid, Kriens, Switzerland) of a maxillary arch with 4 internal connection 3.75 × 10-mm implants (IOSS310; 3i Implant Innovations, Inc) was fabricated (Fig. 1, *A*). The 4 implants in the acrylic resin model were sequentially numbered 1 through 4 from left to right (Fig. 1, *B*). Forty-five identical 2-mm–thick custom impression trays were made with light-polymerizing composite methacrylate resin (Palatray XL; Heraeus Kulzer, Hanau, Germany), prepared according to the manufacturer's instructions. The 4 implants in the resin model were covered by 2 layers of baseplate wax (Tenasyle; Imadent, Torino, Italy) to allow a consistent thickness of impression material, and an irreversible hydrocolloid (Xantalgin Select fast set; Heraeus Kulzer GmbH & Co) impression was made to obtain a single cast on which all custom trays were molded. Tissue stops were incorporated between each implant. Three location marks (circular depressions 2 mm wide and 1 mm deep) were made on the base of the acrylic resin model (2 posterior marks between implant number 1 and implant number 4, 1 anterior mark between implant

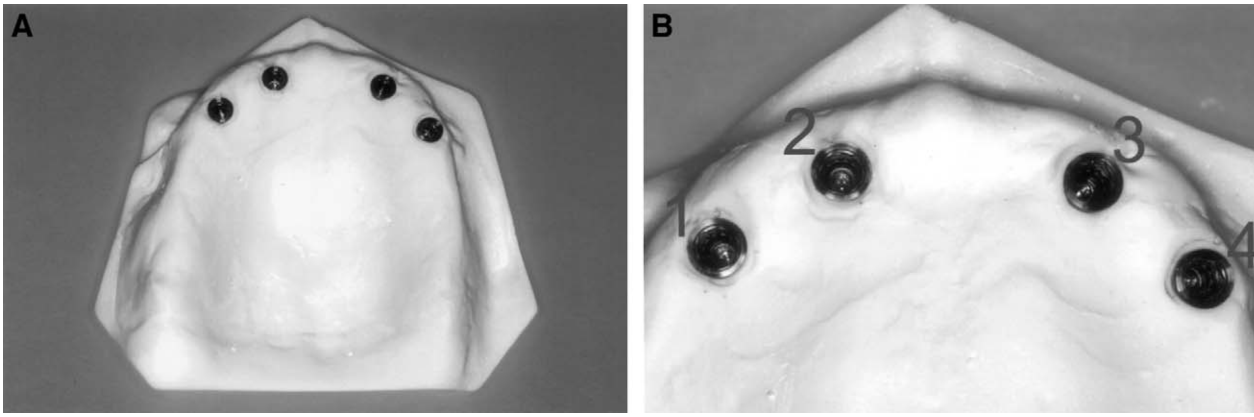

Fig. 1. A, Reference acrylic resin model with 4 internal connection implant replicas. **B,** Implants were numbered 1 to 4 (right to left). Distances were measured with profile projector: sharp edges of projected silhouetted form of implants became reference points of measurement. Distance between posterior implants (#1 and #4) was 28,160 μm and between anterior implants (#2 and #3) was 12,910 μm.

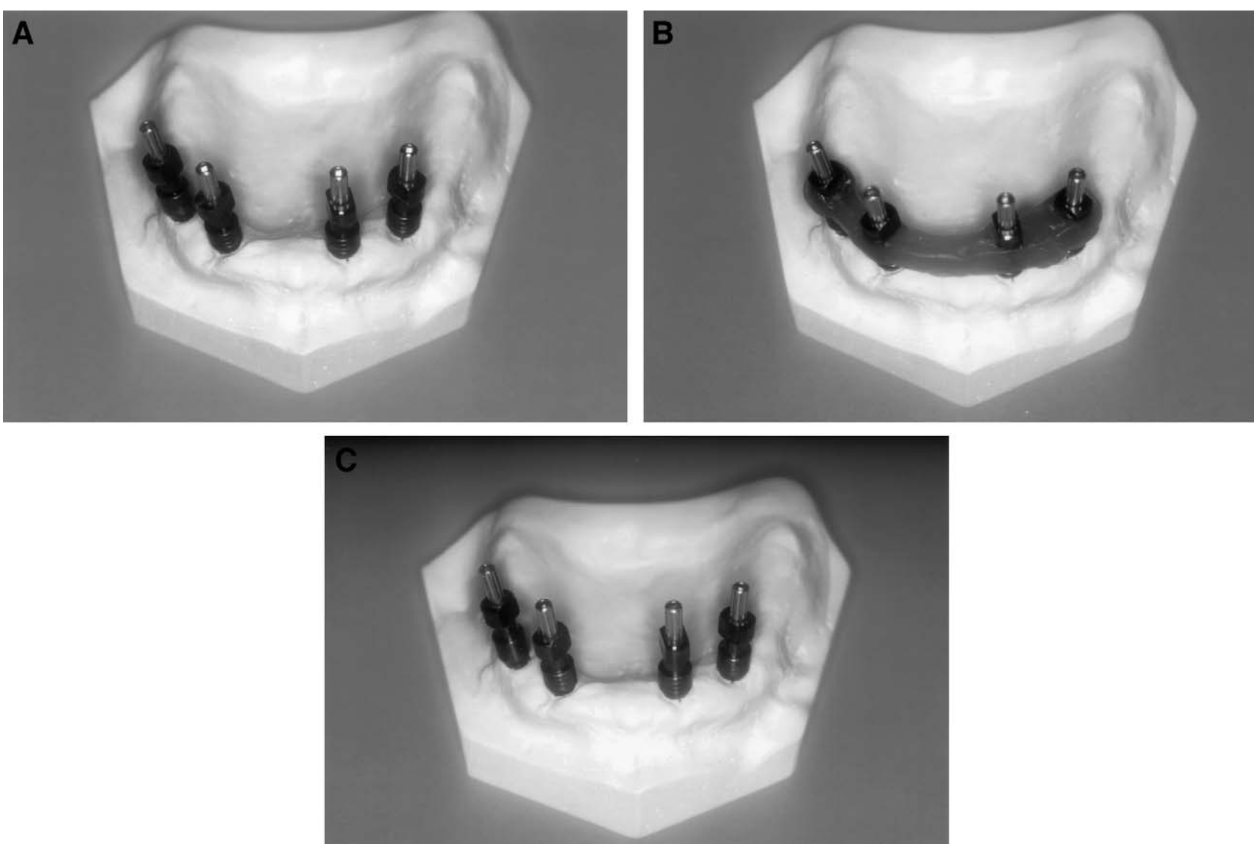

Fig. 2. A, Nonmodified square impression copings (Group NM). **B,** Nonmodified square impression copings rigidly splinted with acrylic resin prior to impression procedure (Group R). **C,** Square impression copings previously airborne-particle abraded and coated with impression adhesive (Group M).

number 2 and implant number 3) and included in the impression trays to standardize tray positioning during impression making. The impression trays, which had 4 openings to allow access for the copings screws, were coated with polyether adhesive (Impregum; 3M ESPE, Seefeld, Germany) 1 hour before each impression was made. The impression copings were secured with 10-mm flat-head guide pins (3i Implant Innovations, Inc) on the implants using a torque wrench (Torque Driver CATDO; 3i Implant Innovations, Inc) calibrated at 10

N·cm. Forty-five medium-consistency polyether impressions [1,16] (Impregum Penta; 3M ESPE) were made according to the manufacturer's directions. The impression material was machine-mixed (Pentamix; 3M ESPE), and part of the material was meticulously syringed around the impression copings to ensure complete coverage of the copings. The remaining impression material was used to load the impression tray. The impression tray was lowered over the reference resin model until the tray was fully seated on the 3 location marks and maintained in position throughout the polymerization time. Five minutes were allowed for polymerization of the impression material. Fifteen impressions with new square impression copings were made for each of 3 different impression techniques represented by the 3 groups.

In the first group, impression copings as supplied by the manufacturer were used (nonmodified square impression copings: NM group) (Fig. 2, *A*). Each impression tray was seated, and the material was allowed to polymerize. The guide pins were released so that the transfer copings remained in the impression when the impression was removed.

In the second group (R group), impression copings were splinted with acrylic resin (Duralay; Reliance Dental Manufacturing, Worth, Ill) (Fig. 2, *B*). The acrylic resin splint was fabricated 1 day prior to the impression procedure and divided into 4 separate pieces with a handpiece diamond disk (Komet 911H; Gebr. Brasseler GmbH, Lemgo, Germany) and a 0.2-mm standardized gap space was left between the single pieces. The pieces were reconnected just before the impression procedure with an incremental application technique to minimize polymerization shrinkage of the resin.[26,27] The impression procedure was accomplished as previously described.

In the third group, impression copings were airborne-particle abraded and coated with adhesive (Impregum; 3M ESPE), as previously described[25,28] (modified square impression copings: M group) (Fig. 2, *C*). The impression procedure was accomplished as previously described.

New matching implant replicas (IILA20; 3i Implant Innovations Inc) were fastened to the impression copings in the impressions using the same torque wrench calibrated at 10 N·cm. An ADA Type IV die stone (New Fujirock; GC Corp, Tokyo, Japan) was used in accordance with the manufacturer's instructions. The casts were retrieved from the impressions after 24 hours. All casts were stored at room temperature for a minimum of 24 hours before measurements were made. All clinical and laboratory procedures were performed by the same operator.

A single calibrated examiner blinded to the nature of the impression technique used examined all definitive casts to evaluate the positional accuracy of the implant replica heads using a profile projector (Nikon Profile Projector model V-12; Nikon Corp, Tokyo, Japan). All casts were secured to a universal movable surveyor table (Ney, Hartford, Conn), and the 3-dimensional position was adjusted so that the horizontal reference plane of the profile projector coincided with the plane connecting the highest points located at the periphery of the 2 most distal implants. This procedure allowed reproducible 3-dimensional positioning of all 45 experimental casts. The profile projector consisted of a screen with horizontal and vertical reference lines and was equipped with a light source to project a magnified image of the object onto the screen in the form of a shadow (original magnification $\times$ 10). The profile projector allowed measurement of linear distances with an accuracy of 2 μm. The following measurements (Fig. 1, *B*) were evaluated on the reference control acrylic resin model and the definitive cast replicas: (1) the distance between the external sharp edges of the projected silhouetted form of the most distal left and right implants (1 and 4), and (2) the distance between the external sharp edges of the projected silhouetted form of the most mesial left and right implants (2 and 3). Two measurements were made per specimen. No 3-dimensional positional changes of the casts on the surveyor table were required when calculating these distances. Other measurements were not performed to avoid introducing additional sources of measurement error and ensure better data reproducibility.

An intra-class correlation coefficient was used to evaluate operator variability. For this purpose, 10 repeated measurements of the distances between the 2 posterior implants and the 2 anterior implants were carried out in 1 randomly selected cast from each group. Data were analyzed with a 1-way analysis of variance (ANOVA) at α=.05 and n = 15, followed by Student Newman-Keuls multiple comparison procedures to evaluate group means (α=.05).

Table I. One-way ANOVA of horizontal distances measured between posterior and anterior implants on definitive casts obtained with 3 different impression techniques

Distance	F value	*P* value	Scheffe contrasts
Between posterior implants #1 and #4	8.58	.001	NM,M>R*
Between anterior implants #2 and #3	8.76	.001	NM,M>R*

*Group R definitive casts were significantly different for both horizontal distances from definitive casts of groups NM and M.

RESULTS

Relative to intraoperator variability, for each of the distances between posterior and anterior implants in the definitive casts selected from groups NM, R, and

Table II. Variations between resin model and 3 impression groups with respect to horizontal distance between posterior implants (#1 and #4) and horizontal distance between anterior implants (#2 and #3)

		Horizontal distance between posterior implants #1 and #4		Horizontal distance between anterior implants #2 and #3	
Impression group	N	Mean (μm)	SD (±)	Mean (μm)	SD (±)
Group NM: nonmodified, nonsplinted square impression copings	15	46.21	8.9	43.23	8.7
Group R: splinted square impression copings	15	18.17	6.4	15.23	5.9
Group M: Airborne-particle-abraded and adhesive-coated square impression copings	15	41.27	8.4	38.17	8.3

M, the range of standard deviations of the 10 repeated measurements was 3.2 to 3.4 μm, while the range of the intra-class correlation coefficients was 0.93 to 0.96. The small standard deviations and the high values of the intra-class correlation coefficients indicate the reliability of the measurement method.

With the use of the profile projector, numerical differences in changes in implant position were evaluated. One-way ANOVA (Table I) revealed significant differences for both horizontal distances ($P<.001$) between definitive casts from groups R and NM and between definitive casts from groups R and M.

Horizontal variations between the reference acrylic resin model and the 3 groups with respect to implants 1 and 4 (posterior) and implants 2 and 3 (anterior) were analyzed with the Newman-Keuls test. The variation was intended to be the difference between the distance measured in the reference model and the distances measured in the definitive casts. Distances between the 2 posterior implants were all greater than those recorded on the resin model; group NM and group M variation from the acrylic resin model was significantly greater than that of group R (P=.05). The distance between implants 1 and 4 was 28,160 μm on the reference resin model. The distance was 46.21 μm (SD ± 8.9) greater on group NM casts, 18.17 μm (SD ± 6.4) greater on group R casts, and 41.27 μm (SD ± 8.4) greater on group M casts (Table II).

Distances between the anterior implants were also greater than those recorded on the acrylic resin model; group NM and group M variation from the resin model was significantly greater than that of group R (P=.05). The distance between implants 2 and 3 was 12,910 μm on the reference resin model. The distance was 43.23 μm (SD ± 8.7) greater on group NM casts, 15.23 μm (SD ± 5.9) greater on group R casts, and 38.17 μm (SD ± 8.3) greater on group M casts (Table II).

DISCUSSION

In implant prosthodontics, a successful result can be achieved only when passively fitting prostheses are fabricated.[10,11] The application of undue torque to screws during attachment of the superstructure to the abutments may jeopardize the outcome. If a clinically passive fit is not achieved and the metal supporting structure is unstable intraorally, the metal framework is usually sectioned, repositioned, and soldered. To eliminate discrepancies in fit, including those not visually detectable, it is essential that the prosthesis be fabricated on a definitive cast that reproduces, as accurately as possible, the position of the abutments intraorally.

An important factor that influences precision of fit is impression accuracy. The results of the present study do not confirm the results of a previous investigation of impression techniques for multiple external hexagon implants.[25] With multiple external hexagon implants, improved accuracy of the definitive cast was equally accomplished when the impression technique involved square impression copings joined together with autopolymerizing acrylic resin or square impression copings that had been airborne-particle abraded and coated with adhesive. Those results suggested the importance of avoiding movement of the impression copings inside the impression material throughout procedures associated with fabrication of the definitive cast. Unscrewing the guide pins from the impression copings when the tray is removed or screwing the matching implant replicas in the impression may cause minor movement and thus influence cast accuracy. From the results of the present study the authors hypothesize that a higher level of stress between impression material and impression copings is created when an impression with impression copings is removed from internal connection implants, rather than from regular external hexagon implants. This stress may hypothetically induce permanent deformation of impression material or movement of the impression copings inside the impression material. Theoretically, airborne-particle abrasion and adhesive coating of the impression copings should decrease the degree of micromovement of the copings inside the impression material from recovery of the impression to fabrication of the cast and result in a definitive cast that closely replicates the clinical situation. This was shown in 2 previous studies, the first[28] studying impression techniques in the single tooth implant restoration, and a second studying multiple implants.[25] Both studies were related to impression procedures for regular external hexagon implants. For impression procedures for multiple internal connection implants, only the strength of the acrylic resin bond decreased the influence of polymerization shrinkage of impression material and prevented movement of the impression copings inside the impression material itself. The results of the present study suggest that when impression copings are splinted with acrylic resin, more accurate definitive casts can be obtained for internal connection implants than when unsplinted or airborne-particle–abraded, adhesive-coated impression copings are used. These results are in agreement with previous research,[1,14-19] and yet they conflict with findings of other studies.[22,23]

In the present study, the use of the 2 selected measurements between the external edges of the most mesial and distal implants was dictated by the fact that this evaluation did not require positional changes of the cast during the measurements. Further assessments such as the distance between the mesial and distal implants on one side or the other involved various adjustments of the cast position, which would have introduced an additional source of error to the measurements.

Differences in the accuracy of definitive casts obtained with the 3 procedures were found to be significant. The spatial orientation of the implant replicas on definitive casts obtained from impression group R (the acrylic resin splinted impression coping group) corresponded closely to the measured spatial position of the implant replicas in the test model. Consequently, the laboratory technician may fabricate a restoration that may require fewer corrective procedures. However, connecting the impression copings with acrylic resin is a time-consuming procedure. To avoid problems related to resin polymerization contraction and to save chair time, the resin scaffold may be prepared in advance, and the final connection may be performed just before the impression procedure by resplinting a narrow gap space between the implants with a powder and liquid brush application technique using a minimum of material to reduce the effects of polymerization shrinkage when indexing.[26,27]

It is of interest that throughout this investigation, an exact reproduction of implant position was never accomplished. Interimplant distances in the group R casts always expanded. Clinically, this implies that precise fit of a superstructure may be unattainable on definitive casts from any impression technique and laboratory procedure currently in use and that the terms *precision* and *fit* are relative to the clinical assessment by the operator.

It should be noted that the 4 internal connection implants in the reference resin model of this study were almost parallel, which facilitated the removal of the nonmodified square impression copings rigidly splinted with acrylic resin from the reference resin model after the polymerization of the impression material. Clinically, implants positioned in the maxillary arch are often angled to the labial/buccal or in nonaxial or nonparallel orientation to each other. The removal of rigidly splinted internal configuration impression copings may be impossible, thereby necessitating use of nonsplinted impression copings. This may result in a less precise definitive cast. Although the results were not significantly different between groups NM (impressions with nonmodified square impression copings) and M (impressions with square impression copings previously airborne-particle abraded and coated with impression adhesive), interimplant distances in the group M definitive casts showed a lesser amount of expansion than in the group NM definitive casts (Table II). When copings rigidly splinted prior to the impression procedure cannot be used because of the divergent angulations of the implants, it might be preferable to use square impression copings previously airborne-particle abraded and coated with adhesive.

Although polyether has been suggested as the material of choice for implant impression procedures, [1,16] the use of a more elastic impression material, for example a vinyl polysiloxane material, may hypothetically reduce the permanent deformation of impression material determined by the stress between the material and impression copings created when an impression with the copings is removed from internal connection implants.

The differences detected between control (the acrylic resin model) and experimental definitive casts was less than 50 μm. It should be noted that these discrepancies were evaluated in a horizontal plane between paired implants. Under clinical conditions and in multiple implant restorations, these differences may be greater if the discrepancies are present in other spatial planes and if they occur in opposite dimensions. Thus, such discrepancies may clinically result in a nonprecise fit of the metal supporting structure and potential need for soldering procedures. Further studies are required to evaluate the clinical relevance of 3-dimensional movements of impression copings inside the impression material.

CONCLUSIONS

Within the limitations of this in vitro study, casts retrieved from transfer impressions with nonmodified implant impression copings and with airborne-particle–abraded, adhesive-coated copings were statistically less accurate than casts from square impression copings joined together with autopolymerizing acrylic resin prior to the impression procedure.

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Noteworthy Abstracts of the Current Literature

Interdental papilla management: a review and classification of the therapeutic approaches
Prato GPP, Rotundo R, Cortellini P, Tinti C, Azzi R. *Int J Periodontics Restorative Dent* 2004;24:246-55.

Several reasons contribute to the loss of interdental papillae and the establishment of "black triangles" between teeth. The most common reason in the adult population is loss of periodontal support because of plaque-associated lesions. However, abnormal tooth shape, improper contours of prosthetic restorations, and traumatic oral hygiene procedures may also negatively influence the outline of the interdental soft tissues. Several surgical and nonsurgical techniques have been proposed to treat soft tissue deformities and manage the interproximal space. The nonsurgical approaches (orthodontic, prosthetic, and restorative procedures) modify the interproximal space, thereby inducing modifications to the soft tissues. The surgical techniques aim to recontour, preserve, or reconstruct the soft tissue between teeth and implants. This review categorizes the various approaches in different clinical situations.—*Reprinted with permission of Quintessence Publishing.*