A Novel Technique of Impression Making of CAD/CAM Custom Abutments When Fabricating Multi-Unit Implant Prostheses

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Abstract

Background: This manuscript details the clinical steps and advantages of a novel CAD/CAM custom abutment impression making procedure. CAD/CAM technology makes it possible to create matched abutment duplicates that when used intraorally and simultaneously in the laboratory, help to counteract many typical master cast implant replica positional inaccuracies.

Methods: After a traditional impression of dental implants, a diagnostic wax up guides the fabrication of 2 identical sets of custom abutments. One set is installed intraorally and impressed with pre-fitted, connected acrylic copings. The master cast is poured with the duplicate abutments locked into the acrylic copings which were picked-up intraorally and embedded in the impression.

Results: This duplicate abutment impression technique improves implant replica positional accuracy within the master cast by eliminating the compound inaccuracy effects of implant divergence, inter-implant distance, impression material volume, and the repeated screwing in, and unscrewing out, of abutments. Duplicate abutments provide the laboratory technician with exact abutment shape and margin configuration for improved overall final restoration fit. Additional chairside time-savings result from the elimination of retraction cord packing that is traditionally employed to cleanly impress abutment margin configurations. This results in improved peri-implant soft tissue management throughout the entire case.

Conclusions: This duplicate abutment impression procedure offers both clinicians and laboratory technicians improved implant master cast replica positioning for more reliable implant prosthesis fabrication. Duplicate abutments simplify clinical impression making while optimizing the final restoration's fit and margin adaptation.

KEY WORDS: CAD/CAM, implants, abutments, duplicate, impression, accuracy.

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INTRODUCTION

Many new methods and techniques have evolved during the past forty years during the dental implant surgical and restorative evolution. While numerous studies have focused on the successful biologic bone response to osseointegration, the technical imperfections that frequently occur during the fabrication of implant prosthesis have continually required Implantology to develop predictable clinical Prosthodontic solutions.[1-5] Impression accuracy is one area of ongoing implant prosthodontic research and development, that is attempting to improve the reliability of transferring the intraoral anatomy to the laboratory for prosthesis fabrication.[6] Despite the many impression innovations that have been developed in the hopes of improving the accuracy of the working cast (i.e. splinted coping transfers, or transfers of disposable plastic caps), a predictable, dimensionally accurate impression procedure, has still not been confirmed as "reliably accurate" case-after-case.

Research has provided insight into utilizing impression methodologies that will improve transfer accuracy. Some studies suggest that an open tray technique has accuracy advantages, while other studies illustrate the a closed tray technique is superior.[6] However, the same review concludes that neither approach is truly more accurate than its' alternative.[6] It appears that a more important consideration is that metal impression trays have been shown to yield more accurate impressions than plastic impression trays, likely due to the reduced flexibility of metal trays.[7]

Studies indicate that greater cast discrepancies result between the original implant position and its' working cast counterpart when significantly angled implants are impressed when compared to more vertically aligned implants. Impression accuracy can also be adversely affected by divergence between the implant axis and the final crown axis. This problem has been somewhat lessened with the use of custom abutments that, within their morphologic design, can minimize the degree of divergence between these two restoration components.[8-10]

Custom Abutments provide a biologic and esthetic abutment option that combines ideal abutment shape, improved-fit features over stock abutments, that also can guide soft tissue contouring with the abutment's emergence profile.[11,12] Another significant advantage of using custom abutments is the ease with which the preparation margin can be placed just below the level of the soft tissue crest, which can help prevent cementitis.[13-15] Custom Abutments duplicates can be employed during final prosthesis master impression making procedures, to improve working cast accuracy. Duplicate abutments are identical copies of the original abutment with matching morphology and margin designs (Atlantis Abutments and Gemini Duplicate Abutments, Astratech-Atlantis division of Dentsply Corp, Mölndal, Sweden).[16]

Utilizing splinted custom abutment transfer copings that fit both the custom abutment and its' duplicate precisely (rather than impressing the abutments themselves) is another known method to improve replica positioning. Using a closed tray with splinted transfer copings impressed with polyvinyl siloxane further improves accuracy.[17,18] Lastly, studies do reveal that when impressing 4 or more implants, the coping transfer pick-up technique

performed with a metal tray, resulted in the best replica positioning.[6] In a complex multi-unit implant restoration, duplicate abutments facilitate the inclusion of all these accuracy fac - tors within the impression making procedure to improve the reliability of the working cast.

Another impression accuracy problem, that often adds significant time when performing a full mouth implant reconstruction impression, is the repeated screwing in, and unscrew - ing out, of temporary healing caps, tempo- rary abutments, and definitive abutments. The initial placement and subsequent removal of these differing implant components, is usually required to successfully perform final restora - tion impression making procedures when mul- tiple implants are involved. These component insertions and removals can worsen the accu - racy of the created final impression because of the increased likelihood of imperfectly seating the many different components. Using dupli- cate abutments minimizes the time required to perform the repeated component part insertions and removals that is common to multi-implant prosthesis impression making procedures.

CL I NICA L TEC HN I QU E

Two important goals to strive for when performing impression making pro- cedures for the fabrication of com - plex multi-unit implant restorations are:

1. To minimize the positional inaccuracies of the implants and the abutments when captured within the impression material.
2. To reduce chairside working time while capturing an accurate multi-unit implant working cast impression.

These goals can be readily achieved with by using duplicate custom abutments and by incorporating into the impression-mak- ing procedure, the studied factors known to reduce implant impression making inaccuracy:

1. Minimize implant divergence issues by designing custom abutments that counter the divergence.
2. Utilize 2 identical sets of custom abut- ments which are fabricated prior to the mak- ing of the final restoration impression.
3. Minimize the distance between implants with the abutments' anatomical form, which reduces the inter-abutment vol- ume of impression material required.
4. Use custom-created impression copings that precisely fit over the entire preparation surface of the custom abutment. Use a metal tray.

S TEP 1: Impression of All Implants That Will Support the Final Restoration.

An implant level Impression is initially made by fitting each implant with its' companion appro- priately sized impression coping. All copings are then positionally captured with polyvinyl siloxane impression material (Honigum Light, Honigum Mixtar Mono, DMG, Hamburg, Ger - many) in a closed tray procedure using a rim lock stock metal tray (Fig. 1). Perfect trans - fer of the implants positions and angula- tions is not crucial at this time, because the cast poured from this impression will be used solely to design the CAD/CAM abutments. These master casts are articulated for scan - ning, waxing and virtual abutment design virtual (Fig. 2). Any slight positional errors of the rep - licas can be compensated for by he design the of abutment wall taper angle. More accu - rate abutment positions will be captured dur-

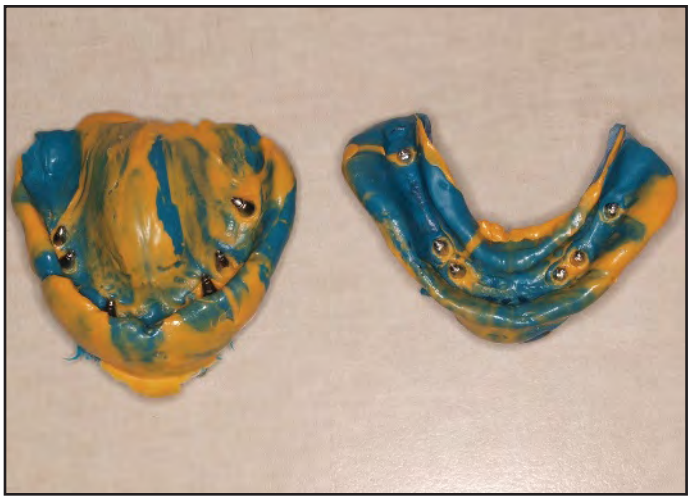

Figure 1: **Impression Copings Impressed with Polyvinyl Siloxane impression Material.**

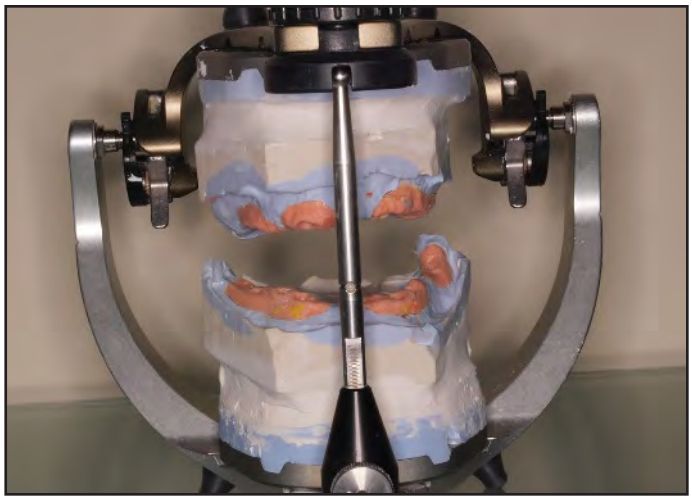

Figure 2: **Articulated master casts made from initial Polyvinyl Siloxane impressions.**

Figure 3: **Removable Maxillary Diagnostic Wax up.**

Figure 4: **Silicone Matrix of wax up to fabricate provisional restoration.**

ing the final restoration impression procedure.

In order to fabricate the CAD/CAM abut - ments, a removable diagnostic wax up (Fig. 3), and a silicone matrix (Fig. 4) (Picodent Esthetic-Gum, Picodent, Wipperfürth, Ger - many) of the wax up, are created upon the first working cast. The wax up guides the design so that each abutment has a preparation con - tour that fits within the confines of the final restoration. The silicone matrix facilitates the fabrication of the provisional restoration (Fig 5).

Once the wax up is completed, it is scanned, and combined with scans of the master casts, to guide the virtual abutment design (Figs. 6, 7). When virtual design is completed, 2 sets of the abutments are milled in titanium with sur- face retentive grooves, to increase the retention of the final restoration. One set of abutments

Figure 5: **Maxillary provisional made from silicone key.**

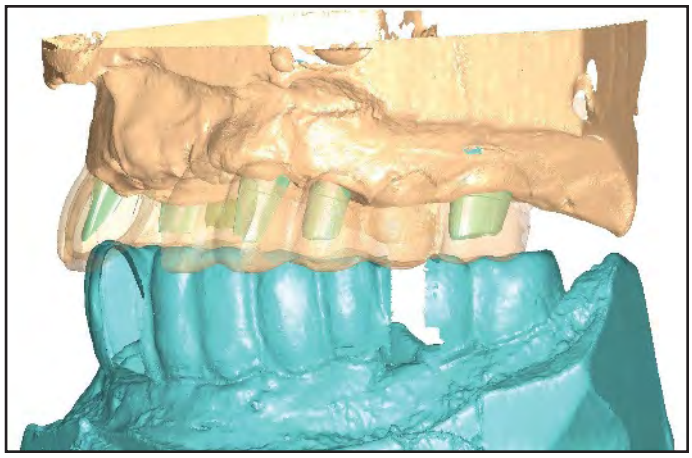

Figure 6: **Scanned maxillary wax up silhouette vs. mandibular wax up scan guiding maxillary abutment design.**

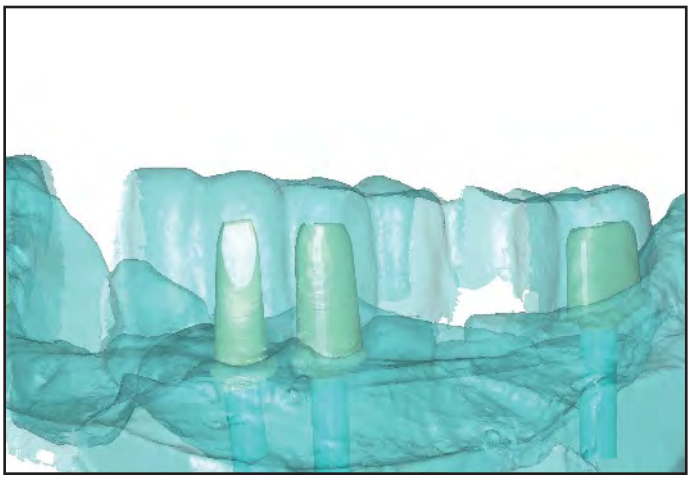

Figure 7: **Mandibular scanned provisional wax up guiding posterior abutment design.**

Figure 8: **Milled titanium abutments installed on master cast.**

is installed in to the articulated master casts, and the other is placed intraorally (Figs. 8, 9).

S TEP 2: Installation of the Custom Made Abutments.

Prior to installing the custom made abutments, acrylic resin positioning keys are fabricated on the initial working cast (GC Pattern Resin, GC Corp, Japan) The resin keys should contain buccal and lingual wings (Fig. 10). These wings when embedded in the impression, will secure the keys' position. When there are two or more adjacent implants, it is not necessary to make occlusal surface wings. Because the resin bar connecting the adjacent abutments will adequately secure the proper position of abutments during the upcoming final impression procedure.

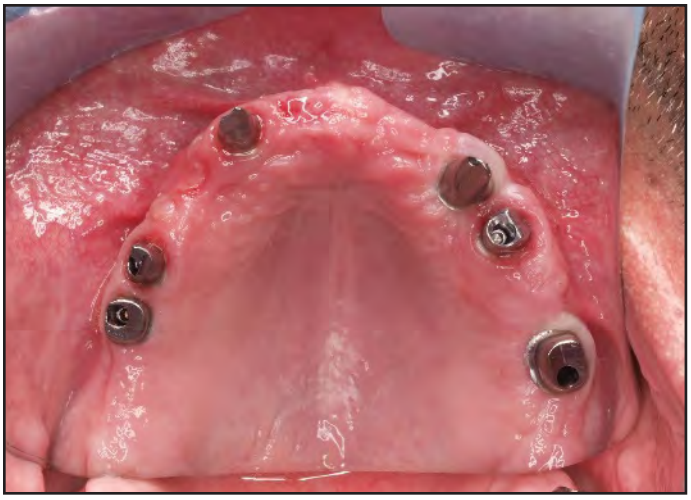

Figure 9: **Maxillary custom abutments installed intraorally.**

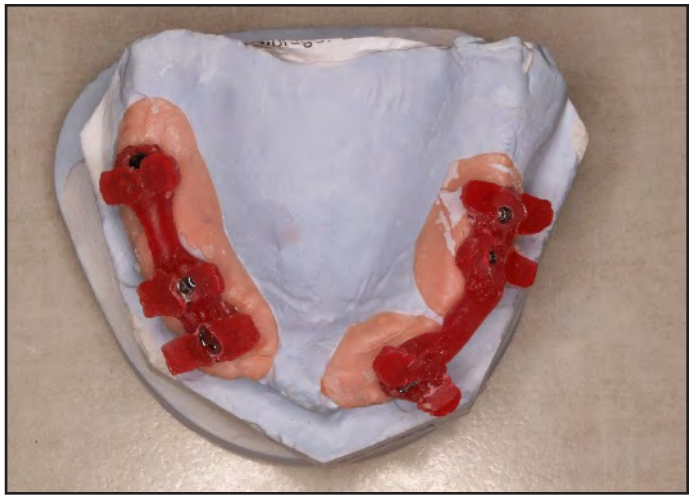

Figure 10: **Resin keys with retentive wings fabricated upon the custom abutments for use in the final restoration impression procedure.**

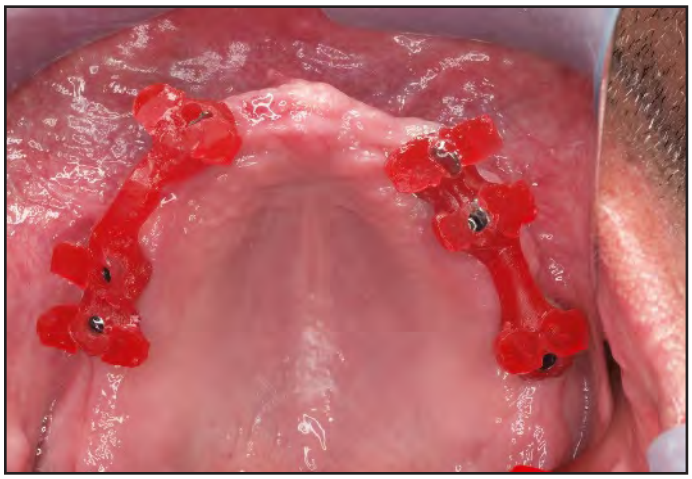

Figure 11a: **Maxillary resin positioning keys in place.**

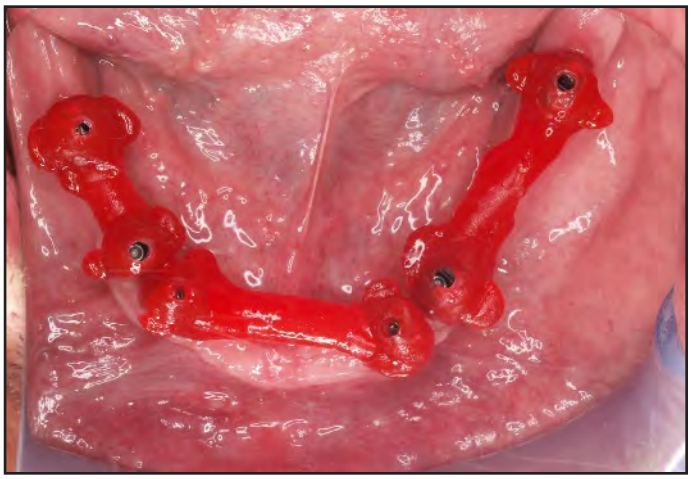

Figure 11b: **Mandibular resin positioning keys in place.**

S TEP 3: Impression of the Custom Abutments

Each abutment is seated intraorally using the positioning keys (Figs. 11 a, b). At this point, the resin keys are sectioned to individualize each abutment (Figs. 12 a, b). Next, firmly seat each resin key section onto its' abutment and recon - nect the bar sections back together with Pat - tern Resin. Lastly, in a stock metal rim lock tray, a 1-step putty and light body polyvinyl siloxane impression of the acrylic bar is made (Honigum Light, Honigum Mixtar Mono, DMG, Hamburg, Germany). When the impression is fully polym - erized, the tray is removed with the acrylic key embedded in the body of the impression. What is of note here in step 3, is the absence of cord

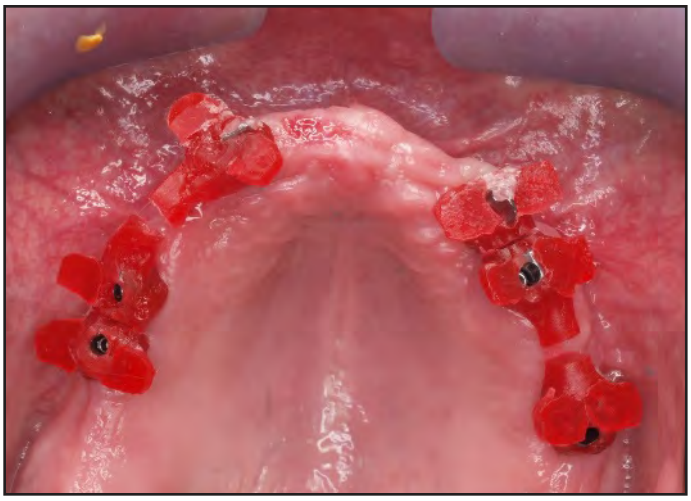

Figure 12a: **Maxillary resin keys are sectioned to individualize each abutment.**

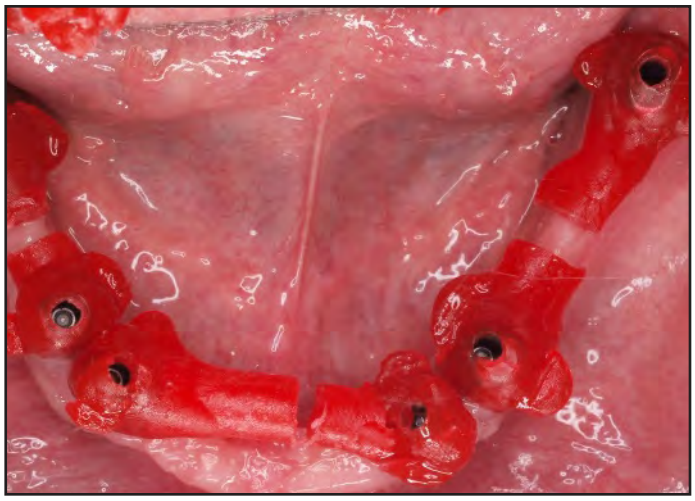

Figure 12b: **Mandibular resin keys are sectioned to individualize each abutment.**

Figure 13: **Installed provisional restorations made from silicone keys developed from original wax up.**

packing to obtain clean restorative margins. With duplicate abutment impression technique, this very time consuming, and often arduous clinical procedure, is completely unnecessary because the duplicates contain the exact margins of the intraoral set of abutments.

The silicone matrix of the abutment design wax-up is used to fabricate the provisional restorations (Fig.13). If the provisional material does not flow completely down to the margin because of its' subgingival location, the margin can be corrected by inserting a duplicate abutment into the partially formed provisional abutment retainer and flowing composite or acrylic over the exposed visible margin of the duplicate. Once all abutment margins are corrected in this fashion, the provisional can be installed onto the intraoral set of abutments.

S TEP 4: Inserting Abutment Duplicates into the Impression.

All duplicate abutments are connected to their replicas, and then placed into their respective locations within the acrylic key that is embedded within the impression material (Figs. 14a, b). The duplicates with implant analogues will fit precisely into the acrylic keys in the same way the intraoral set of abutments did before the impression was made.

Figure 14a: **Maxillary analogs connected to the duplicate abutments, which are installed into the acrylic resin keys that were "picked up" in the PVS impression.**

Figure 14b: **Mandibular analogs connected to the duplicate abutments, which are installed into the acrylic resin keys that were "picked up" in the PVS impression.**

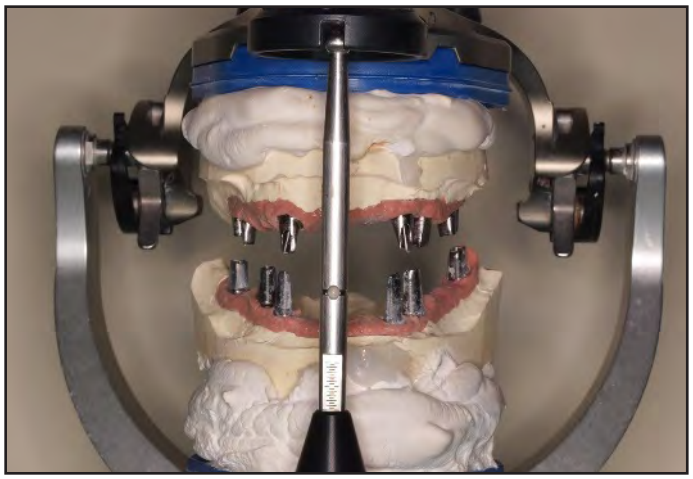

Figure 15: **Articulated master casts with duplicate abutments ready for restoration fabrication.**

S TEP 5: Pouring the Master Cast.

The impression containing the duplicates with their analogues attached are poured with artificial silicone gingival (Majesthetic®-Gingiimplant, Picodent, Wipperfürth, Germany) which facilitates simpler cast release from the impression. If artificial gingiva is not utilized, subgingival duplicate abutment contours will need to be waxed out to enhance stone release during cast recovery. The master casts are then articulated (Fig. 15) such that the dental technician can use the duplicate abutments in the same fashion that traditional stone dies are used to fabricate the final restoration for intraoral insertion (Figs. 16a, b, and 17a, b). Note in figures 17a and b, the excellent adaptation of the final restorative margins to the peri-implant tissue crests. This is the result of the subgingival placement of the abutment margins during virtual abutment design.

DISC USSIO N

The described duplicate abutment impression making procedure, can be employed with either titanium (Figs. 8, 9) or nitrate coated titanium abutments (Gold-hue, Astratech-Atlantis division of Dentsply Corp, Mölndal, Sweden) (Fig. 19), because metallic abutments do not change shape once they are milled. Metallic duplicates are manufactured by using the same abutment CAD design files to guide the mill-

Figure 16a: **Facial view of mandibular completed prosthesis on master cast without tissue replica.**

Figure 16b: **Palatal view of completed maxillary prosthesis on master cast with tissue replica.**

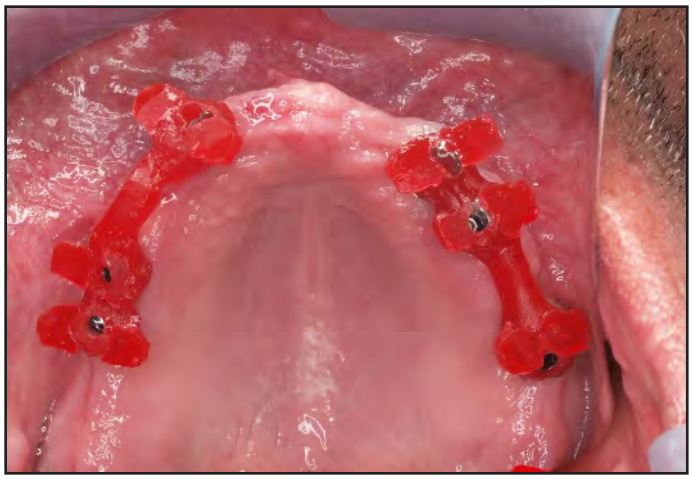

Figure 17a: **Left view of the final restoration placed upon intraoral set of abutments.**

Figure17b: **Right view of the final restoration placed upon intraoral set of abutments.**

ing of 2 equal-sized abutments. Alternatively, because zirconia undergoes sintering shrinkage during fabrication, it is not possible to make two identical Zirconia abutments. When a zirconia custom abutment is used intraorally, the prosthetic procedures must be performed in the traditional way, by making the abutment level impression with retraction cord.

It has been written that whenever possible, discrepancies between the working cast and the intraoral condition should be avoided.[19] A very important potential improvement of this technique over conventional impression making, is the accuracy of data that is captured within the impression. Regardless of whether a splinted impression technique is used with

Figure 18: **Patient prior to implant therapy.**

Figure 19: **Gold hue titanium nitride coated abutments can be duplicated in a similar fashion as titanium abutments.**

an open or closed tray, angular implant differences routinely result in inaccurate replica position.[20] In cases where there exists significant implant divergence, the CAD/CAM abutments can be designed with near- parallel abutment walls of all abutments, so that the implant divergence is no longer a factor affecting impression accuracy. The abutment walls now become what is being impressed (rather than implant position within the alveolus) so that the position of divergent implants is not the focus of the impression. Despite reports that improved impression accuracy has been obtained when implant level impressions are made compared to those made at the abutment level,[21] by lessening the effect implant divergence has on impression accuracy, the described duplicate abutment technique counters the effect implant divergence has on master cast fabrication.

The described technique's method includes using a splinted technique with custom transfer copings, impressed with polyvinyl siloxane in a closed metal tray. Combining all of these "best accuracy practices" in 1 impression procedure insures that inaccuracy is kept to a minimum.[17,18] Although it has been advocated that polyether materials are more accurate than polyvinyl siloxane materials, the results of some studies do not support this contention.[6,17] Both polyether and polyvinyl siloxane can be used to accomplish the described technique. But when using polyvinyl siloxane, the 1-step putty combined with a light-body syringe material was more found to accurate than a 2-step polyvinyl siloxane impression using a wash technique.[6]

In addition to the potential accuracy improvements previously described, there are peri-implant tissue health improvements that result from using one-piece custom made CAD/CAM abutments. First, titanium and titanium nitride are well accepted by the peri-implant tissues such that studies indicate that titanium abutment materials enhance soft tissue maintenance.[22,23] The mucosal barrier remains

more stable, and demonstrates more collagen and fibroblasts when peri- implant tissues rest against titanium and/or zirconia abutments in contrast to gold or platinum abutments.[10]

Second, CAD design allows for precise control over margin placement (Figs. 17 a, b). Slightly subgingival crown margins, that follow the architecture of the peri-implant sulcus crest, can minimize the likelihood of developing tissue swelling, inflammation (cementits), and possible implant failure.[14, 24-27] Cement extrusion deep into the peri-implant sulcus, is minimized because the restoration margin is placed just below the tissue crest. Therefore, cement removal is simplified. A unique cementing procedure application of duplicate abutments is they make it possible to remove excess cement extraorally, just prior to seating the final restoration intraorally. After placing cement into the crown or bridge units to be cemented, the extraoral set of duplicates can be seated into the castings, to extrude excess cement prior to the cement fully setting. The squeezed out excess cement is quickly removed from the external aspects of the restoration, after which the duplicates can be withdrawn. Then the final restoration is seated onto the intraoral abutments where only a small amount of remaining cement will extrude slightly into the peri-implant tissues. Coating each duplicate with a thin film of petroleum jelly prior to seating them into the castings, helps keep the cement within the casting when the duplicate is withdrawn.

It has been demonstrated that repeated abutment unscrewing can result in peri-implant attachment apparatus injuries that can lead to recession.[28, 29] Using the duplicate technique, the installed abutment never requires additional removal. When fabricating the final implant-supported prosthesis, the various prosthetic components (framework at try-in, porcelain at bisque bake try-in, final restoration at try-in and insertion) can be evaluated without any abutment removal and replacement procedures. This saves chair time, protects the delicate peri-implant soft tissue, and simplifies the entire process for the prosthodontist. Additionally, with this method, repeated anesthesia delivery visit to visit, is unnecessary because the abutments are not repeatedly removed and replaced. Anesthesia can compromise the patient's ability to assist in the occlusal and esthetic verifications because the patient loses occlusal feel capability, and their lips and face can droop, making any final restoration esthetic evaluation impossible to reliably judge.

CONCLUSION

This manuscript details a novel duplicate abutment impression technique that combines together, all of the known, accuracy enhancing impression making techniques in an attempt to improve the dimensional reproduction of the master cast that is used to fabricate the final implant-supported prosthesis. These accuracy enhancing factors are: using rigid metal stock impression trays, using well-fitting custom fitted impression copings, eliminating implant divergence with near-parallel abutment wall design, and reducing the impression material volume between neighboring abutments.

This duplicate abutment impression procedure offers clinicians significant chairside time-savings resultant from eliminating cord packing, and minimizing implant component insertions and removals throughout the entire

process of prosthesis fabrication. This results in improved peri-implant soft tissue management throughout the entire case. Lastly, duplicate abutments simplify final prosthesis fabrication for the laboratory technician, because he/she is using die(s) that are an exact replication of the abutments that are in present a patient's mouth. This makes final restoration fit and margin fabrication and adaptation highly precise.

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Disclosure
The authors report no conflicts of interest with anything mentioned in this article.

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