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Partnering for Success: Bilateral Impacted Canines Restored with Dental Implants: A Case Report

S. Kent Lauson, DDS, MS¹ • Ronald Yaros, DDS²

Abstract

Background: A patient with impacted canines was referred for orthodontic evaluation. The orthodontist determined that the location of the canines prohibited orthodontic correction and the decision was made to extract the teeth and create space for implants.

Methods: Following removal of the impacted canines, orthopedic expansion appliances were used to increase bone structure of maxilla to create space for implants and improve constricted arch. After orthodontics was completed, implants were placed with no need to enhance bone structure to support implants.

Results: Aesthetically pleasing results were achieved with ideal arch form and no extraction of permanent teeth other than the impacted canines.

Conclusions: This case report documents that collaboration between dental providers can provide pleasing results in difficult situations.

KEY WORDS: Dental implants, orthodontics, prosthetics

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INTRODUCTION
In recent years, use of dental implants has become increasingly common and general dentists are expanding their study and use of dental implants to meet this demand. Unfortunately, in the attempt to fill this need, dentists oftentimes may only be able to offer a compromise result or a treatment plan that involves extensive orthognathic surgery and/or full mouth reconstruction. The following case study demonstrates a case in adult orthodontic/orthopedic treatment where no orthognathic surgery was used prior to placement of dental implants.

CASE REPORT
A 37 year old female was seen as a new patient at the general dentist office with a chief complaint of chipped anterior teeth and an “uncomfortable bite.” Examination showed a malocclusion with a crossbite on the right. Radiographs revealed both upper canines to be palatally impacted. A decision was made to refer the patient for evaluation of orthodontic treatment options. The comprehensive evaluation revealed a significant mid-face deficiency, partial anterior and posterior crossbites, but no TMJ dysfunction.

During the evaluation (Figures 1, 2) it was observed that her upper canine teeth were in an extreme impacted position and would be very challenging to safely bring into position orthodontically. The options discussed with the patient were to either work to bring them in orthodontically or remove them to be replaced with implants. Attempting to bring them into place orthodontically would add considerable treatment time and would increase risk to the root structures of the adjacent teeth. It was agreed by the patient that the teeth would be surgically removed which was accomplished without incident.

To address the constricted and underdeveloped maxilla Functional Facial Orthopedics (FFO) was used to accomplish the enhancement needed to help to achieve facial balance and allow the full complement of 28 teeth. A removable, maxillary, three-way sagittal appliance with anterior bite plate was used to accomplish the orthopedic correction. This took eleven months to achieve, at which time fixed orthodontic appliances were placed. The orthodontic phase of treatment lasted 23 months in order to complete the pre-implant objectives. During the final stages of treatment, consultations between the orthodontist and dentist regarding the space needed for the implants were completed. Once the space was considered ideal for the implants and the other orthodontic treatment objectives were achieved, the orthodontic appliances were removed (Figure 3).

Orthodontic retainers with pontics to maintain space at the canine sites were placed followed by regularly scheduled visits for retainer checks during the time the implants were healing. Bilateral canine implants were placed during this time and after three months of healing, custom abutments were fabricated and two porcelain-fused-to-metal crowns were cemented (Figure 4). Due to the excellent occlusion and arch form development with the orthodontic and orthopedics, there were no compromises in the placement or restoration of the implants. The patient was extremely pleased with the cosmetic and functional results, which continues to be stable at seven years post-op (Figure 5) •
Figure 1: Photos before orthodontic/orthopedic treatment.

Figure 2: Panoramic x-ray before orthodontic treatment showing impacted upper canines.
Figure 3: Photos after the completion of orthodontic/orthopedic treatment.

Figure 4: Panoramic x-ray after placement of implants.
Figure 5: Photos after the completion of dental implants.

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

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A New Novel Approach to Guided Dental Implant Surgery

Lambert J. Stumpel, DDS

Abstract

**Background:** Guided surgery holds the promise for very precise implant placement by clinicians with various skill levels. Implementation of the computer version for smaller cases is cost prohibitive due to mandatory CBCT and CAD/CAM involvement. Model based guided surgery, with a low cost novel system, allows 1-2 implant cases to be treated with an in-office system.

**Methods:** A fully restrictive surgical guide is fabricated, in-office, for same-day surgery. Simple bone sounding is used to acquire the bucco-lingual cross-cut information. A simple peri-apical radiograph does reveal the mesio-distal trajectory.

**Result:** The placement of a single implant is planned following exact parameters. Surgery is a simple drill-press like procedure. Final position conform the planning. Immediate impressions allows for the placement of the definitive restoration at the second visit 6 weeks later.

**Conclusion:** Controlled implant placement following precise determination of the 3 dimensional position of a dental implant is possible with a fully restrictive surgical guide. The 3D Click Guide is a low cost, in-office system that does not rely on CBCT information, although CBCT can easily integration if required.

**KEY WORDS:** Dental implants, guided surgery

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**INTRODUCTION**

A dental implant is an object in space, its position defined by coordinates in all 3 dimensional planes; x, y and z. In dentistry those planes are termed mesio-distal, buccal lingual and apical coronal. Each plane is defined following its own specific requirements, which are guided by biologic and prosthetic restraints. During conventional free hand surgery the operator develops an osteotomy in all 3 dimensions mentally combining all in one surgical drill path. Guided surgery with a fully restrictive surgical guide requires each of these planes to be considered individually based on various cross sections. A fully restrictive surgical guide can then be fabricated combining each planes trajectory into a surgical guide, which guides bone drills into a singular path.\(^1\)-\(^9\)

Conventional peri-apical 2 D radiography easily images the mesio-distal and apico – coronal plane. Note though that spatial deformation of the image can occur due to X-ray tube angulation. A radiographic image of the 3\(^{rd}\) dimension requires more specialized tomographic equipment. The Spiral Computerized Tomograph, CT, or the Cone Beam Computerized Tomograph, CBCT. Recent years have seen an explosion of systems made available through various manufactures; a true advance in dentistry, but as always at a cost that has to be justified. Considering that 55-60% of implants are placed by the 18-20% of the US dentists placing implants. (Straumann, AG, public investor data 2012), owning a CBCT machine might not be economically feasible for many. In addition we see that a growing number of clinicians are placing implants, but with a lower total number of implants placed per operator. This of course has implications for the surgical skill compared to clinicians placing many hundreds of implant per year. Fully restrictive guided surgery requires less skill compared to freehand surgery, even in absolute terms it might even produce better result.\(^{10}\)-\(^{12}\) The development of the workforce, more, less experienced, dentist placing implants would make a good argument for fully guided surgery. At the same time controlling the cost of medical care in relation to the outcome will be a future issue. The “3D Click Guide” has been developed to allow for very precise implant placement that is low cost and easily accessible for the common 1-2 implant cases. Case selection is of the utmost importance, knowing when to refer, and knowing when to treat should be made before a case is started, not an afterthought of poor treatment planning. The International Team for Implantology (ITI) has developed an excellent classification sys-

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**Figure 1:** 5 soft tissue depth measurements are taken per implant site. Using only topical anesthetic, a short dental needle and an endodontic stopper. Data acquisition is accomplished in under 1 minute.
tem (SAC-system), which will aid the clinician in matching the case, to their clinical ability. The system has 3 main categories: Straightforward, Advanced and Complex. It even has a web based version of the SAC Assessment Tool, free of charge (www.iti.org). This article depicts a case which would be considered S (straightforward), future articles will show more advanced applications of the 3D Click Guide.

**CLINICAL CASE**

A healthy 45 year old patient presented with a missing lower second premolar. Large torri give the impression of an abundance of bone, but hide a lingual concavity. A stock tray was filled with stiff VPS putty (Examix, GC, Alsip, IL) and covered with a thin sheet of food foil (Saran wrap, SC Johnson, Racine, WI). Once placed in the
mouth finger pressure pushes the putty against the lingual and buccal soft tissue. This will result in a tight adaptation of the soft tissue against the bone. Upon setting, a small portion of new putty was mixed and added to the buccal and lingual of the impression at the treatment area. Again covered with food foil, and placed back into the mouth. Additional finger pressure will push down the soft tissue and actively overextend the impression. The tray was removed from the mouth, as

**Figure 6:** The Buccal and Lingual wings are placed for the ideal Mesio-Distal position, while maintaining the previously set Bucco-Lingual. Note that the MD angle is a best estimate.

**Figure 7:** The finished surgical guide, with the rails exposed once the cross member has been removed.

**Figure 8:** The Radiographic Implant Replica’s (RIR’s) are not overlapping, indicating a non-diagnostic radiograph.

**Figure 9:** The RIR’s overlap, indicating a diagnostic radiograph. The selected Mesio-Buccal trajectory should be rotated 3 degrees towards the distal using the yellow rotation-block.
was the foil. This pre-impression was now filled with injection VPS material and repositioned. The resulting impression captured a much larger area of the crest then we are commonly used to in dentistry. A topical anesthetic was placed and 5 tissue thickness readings performed, with a 27G Short anesthetic needle (Fairfax Dental, Miami, FL) and a rubber endostop (Fig 1).

The impression was poured using dental stone (Earth Stone, Tak System Inc., Whareham, MA) into a base former (Accutray System, Coltene-Whaledent, Inc., Cuyahoga Falls, OH). A dual layer vacuform carrier was created. Using 1mm soft-guard material + 0.75 mm bondable material, heated together (Essix A+ and model duplication material, Dentsply Raintree Essix, Sarasota, FL). The cast was cut along the Mesio-Distal path of the proposed MD axis for the implant. The cut is based on an estimation of neighboring roots and the center of the tooth that will be replaced.

Using radiograph and anatomical information, next was the transfer of the five tissue thickness readings to the cut face of the cast. The markings connect parallel to the soft tissue (Fig. 2).

The desired BL implant axis was marked on the cast relative to bone volume and central fossa. The desired top of implant determined and a 2 mm hole drilled at the implant axis. The top of the implant is generally 2-3 mm below the buccal gingival outline. This placement will place the top surface of the rotation block 9 mm above the shoulder of the implant (9 +1= 10 mm above the drill-guide). The blue Bucco-Lingual Positioner (BLP) was placed in the hole and line up with the drawn axis. Next secured with fast setting Cyanoacrylate glue (Instant Krazy Glue, Krazy Glue, Columbus, OH) (Figs. 3-5). The correction slot of a buccal wing (Yellow) was placed on top of the BLP. The wings/ Radiographic Implant Rep-

**Figure 10:** 3 rotation-blocks are available, 0, 3 and 7 degree.

**Figure 11:** The soft tissue is removed with a diamond bur for flapless implant placement.
lica’s (RIR’s) cut/bend as needed for passive fit. The Lingual wing (White) was attach and adjusted. The complete assembly positioned on top of BLP. The position between the teeth is good since the teeth can be seen; the set angle is a best estimate, requiring X-ray confirmation. The wings and RIR’s were secured with PMMA ortho-acrylic (Ortho Resin, Dentsply, York, PA) to create an irreversible solid connection (Fig. 6). Once the cross-member was removed, the retention rails were exposed (Fig. 7).

The surgical guide was placed in the mouth and a peri-apical radiograph taken. If the RIR’s are not overlapping (Fig. 8), then the radiograph is deformed and does not show the true dimensions. The adjusted tube head of the X-ray unit showing both RIR’s overlapping; the X-ray image is diagnostic. In this case it was determined that the selected mesio-distal trajectory would encroach on the apex of the premolar (Fig. 9). The 3D Click Guide system allows for instantaneous correction of the only aspect that has been estimated; the mesio-distal inclination. It provides a selection of 3 different rotation blocks that click into the rails of the surgical guide: zero degree (green), 3 degree (yellow) and 7 degree (red) (Fig. 10). In this case a 3 degree yellow block was selected to rotate the
trajectory away from the apex of the premolar.

After local anesthetic was given, the soft tissue was removed with a diamond bur. The osteotomy was prepared following the manufacturer’s protocol and an 8 x 4 mm implant placed (Osseo-speed, Astra Tech, Waltham, MA). Good initial stability was confirmed with an ISQ of 75 (Figs. 11-15). An impression coping was placed and a very small quantity of thin VPS was applied, this was allowed to set. This prevented impression material of being pushed into the fresh surgical wound when the full impression was taken. The dental laboratory made the final restoration, which was placed at the second appointment, six weeks after implant placement.
Figure 18: The crown is torqued to 25 N/cm. Note the ideal gingival contours.

Figure 19: The screw access hole is positioned exactly as planned for a screw retained restoration.

Figure 20: The finished restoration, delivered at the second appointment. Six weeks post implant placement.

CONCLUSION
Three-dimension implant placement is driven by clinical and prosthetic requirements. The clinical execution in a free-handed or limited guided manner is still highly dependent on individual operator skill. Fully restrictive surgical guides allow operators with less experience to place implants expertly and experienced clinicians to do so more expediently. Computer generated surgical guides are less economical and time consuming for smaller cases. An analog fully restrictive surgical guide was developed for just those cases. The 3D click Guide is an ‘in-office’ model-based surgical concept using data from bone sounding measurements or, if desired, CBCT.

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Disclosure
Dr. Stumpel reports that he is the CEO, Idondivi, Inc.

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Background: Recent advances in digital technology now allow clinicians to use digital impression techniques to fabricate implant crowns without stone models. However, little data is published on these new techniques. The purpose of this article is to compare clinical crowns produced using optical impressions and conventional impression techniques.

Methods: Patients were randomized in this prospective clinical trial to either conventional impression or digital impression groups. Conventional impressions were made using standard techniques, with an impression coping and polyvinylsiloxane (PVS) impression materials. Digital impressions were made using an optical scanner with a scan body placed on the implant. The following outcomes were recorded: time to insert the crown (seconds), a qualitative assessment of crown quality (scale from 1-4; 1=poor and 4=excellent), and whether the crown required occlusal adjustment.

Results: Eighteen crowns were analyzed in this study, with 9 in each group. The average time to insert a crown manufactured from a digital impression was 120 ± 46 sec.; for the conventional impression group it was 401 ± 334 sec. These were significantly different (p < 0.01). The average qualitative score for crowns made using a digital technique was 3.1 ± 0.6, while the score for conventional impression technique was lower at 2.67 ± 0.7. In the conventional group, 5 crowns required occlusal adjustments. In the digital impression group, only one crown required occlusal adjustments.

Conclusions: Single-implant crowns produced with optical impressions took significantly less time to seat clinically than crowns produced by conventional techniques. Both techniques produced clinically acceptable restorations.

KEY WORDS: Optical impression, implant, crowns, digital impression

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INTRODUCTION

Clinicians strive for more accurate and more efficient impression techniques for prosthodontic restorations. This can be particularly important for implant restorations, where the limited mobility of implants demands greater impression precision.

Recent advances in technology have made optical impressions a viable technique for fixed restorations. Traditional impression techniques are associated with potential sources for error. Christensen cites that flexibility of impression trays, separation of impression material from the tray, and distortion of impression during shipping or inadequate storage can all increase the inaccuracies of the impression prior to pouring. Expansion of dental stone, which can vary from approximately 0.04 to 0.3% (ANSI/ADA 1987), is another source of error associated with conventional impressions. In addition, impressions that are lost, or damaged during removal of an improperly poured cast must be retaken, the cost of which for full-arch impressions using a stock tray can be up to 40 dollars.

Although digital impressions eliminate many of the negative characteristics of conventional impressions, their accuracy compared to conventional impressions is a matter of some controversy in the literature. Ender and Mehl (2011), for example, found no significant difference in the accuracy of digital impressions taken by the Cerec AC Bluecam and the Lava™ Chairside Oral Scanner (Lava COS) system and conventional impressions on an in-vitro model. Syrek et al., however, found that the marginal fit of crowns fabricated using the Lava COS was significantly more accurate than
Lee and Gallucci performed a study in which second year dental students took both conventional and digital impressions to measure efficiency, difficulty, and operator’s preference for the two techniques. They found the total time to take a conventional impression for a single implant site was nearly twice that to take a digital impression. Students also considered the conventional impressions significantly more difficult to perform than the digital impressions, and the majority preferred digital over the conventional technique.

The scanner used in this study is based on the principle of active triangulation using a laser sheet light projection. Because the light projector and imaging aperture automatically move back and forth on a track within the wand, an entire quadrant may be imaged with only three scans (buccal, lingual and occlusal scans). Although the digital scanner has been used effectively to make tooth-supported restorations, the utility of the digital impression for implants restorations is unknown.

The purpose of this study was to compare the clinical acceptability of implant crowns fabricated from intraoral digital impressions (IOS FastScan; IOS Technologies, INC, U.S.A.), to implant crowns fabricated from conventional polyvinylsiloxane (PVS) impressions.

**METHODS**

Single-unit implant restorations were included in this study. All implants included in the study were single implants with an internal hex connection (Tapered Internal Implant; BioHorizons, Birmingham, AL.). Inclusion criteria for this trial included the following:

- Patients of age 19 years old or more
- An integrated and healthy single implant suitable for restoration with a cement-retained crown and a custom CAD/CAM titanium abutment
- Opposing contact in the opposite arch on natural teeth or fixed restorations
- At least one proximal contact
- Able to provide consent for treatment

Patients were recruited from the existing group of patients within the practice. Once enrolled, patients were assigned to treatment groups using random card selection in a randomized block design. The two treatment groups tested were Conventional Impressions (PVS impressions and stone working casts) and Digital Impressions (intraoral optical digital impressions with no stone working cast). The conventional impression was considered the control group.
Patients receiving conventional impressions were treated in the following manner: healing abutments were removed from the implants and impression copings were placed; complete seating of the impression coping was verified clinically using radiographs and/or direct visualization; wax was placed in the hex driver hole to keep out unwanted impression material; the impression was made using plastic stock trays (COE Spacer Disposable Tray; GC America, Alsip, Ill.) and a PVS impression material (Capture; Glidewell Laboratories, Newport Beach, Cal.); a light body PVS was syringed around the impression coping, and a medium body material was used to fill the tray; impression copings were removed, attached to an appropriate analog, and inserted into the impression; opposing casts were fabricated using irreversible hydrocolloid (Identic Singles Fast Set; Patterson Dental, Pelham, Ala.) and metal stock trays (COE Metal Impression Trays; GC America); casts were hand articulated.

Patients receiving digital impressions were treated in the following manner: the healing abutment was removed, and a polyether ether keytone (PEEK) scan abutment was placed (Scan Abutment; Glidewell Laboratories); scan abutments are available for a variety of implant platforms and sizes. The quadrant was then sprayed with a non-reflective powder (IOS Fastscan Powder; Glidewell Laboratories), and scans were captured according to manufacturer’s instructions (IOS Fastscan; Glidewell Laboratories) of the occlusal, lingual, and buccal views of both the mandibular and maxillary quadrant containing the restoration; scans were also made of the distal and mesial interproximal contacts. If the scanning abutment prevented an unobstructed view of the interproximal contacts, it was removed for these scans; last, a buccal scan was made while the patient in the closed into position to serve as a bite registration.

For both groups, cement-retained crowns were fabricated by a single laboratory (Glidewell Laboratories). Crowns were made from monolithic zirconia (Bruxzir; Glidewell Laboratories); abutments were cus-
tom milled titanium CAD/CAM abutments.

Outcome measures for this study were time of insertion, amount of occlusal adjustments required, and a qualitative assessment (1-4) made by a single, experienced clinician. The clinician was blinded to the group or mode of fabrication for each crown by returning only the abutment and crown to the clinician for insertion.

Time to insertion was defined as the length of time required to remove the healing abutment, seat the custom abutment, and insert the crown with appropriate proximal and occlusal contacts. Time was measured with a stopwatch in seconds. Time required to torque the abutment and cement the restoration was not included. After seating the crown, a qualitative ranking between 1 (poor) and 4 (excellent) was given by the dentist with respect to the overall fit and quality of the crown. The following guidelines were used in the ranking:

- **4** - Excellent. Minimal proximal or occlusal adjustments. Crown is properly contoured and has pleasing emergence profiles and esthetics.
- **3** - Good. Some adjustments required on the proximal or occlusal contacts. Crown is properly contoured with pleasing emergence profile and esthetics.
- **2** - Acceptable. Significant adjustments to proximal or occlusal contacts required, but crown is usable. Crown has limitations in contours and esthetics but is clinically acceptable.
- **1** - Unacceptable. Adjustments in the proximal or occlusal contacts make crown unusable. Crown rocks on abutment. Contours are not consistent with physiological requirements and cannot be corrected with adjustments.

Finally, the presence or absence of occlusal adjustment was noted for each crown.

**STATISTICAL ANALYSIS**

Individual Mann-Whitney U tests were conducted to determine whether the time to fit a crown differed between the digital and conventional categories. Results were considered significant with alpha = 0.05. To dismiss the possibility that two outliers, arising from patients whose crowns took an exceptionally long time to fit (1021 and 886 seconds, both conventional impressions) could be responsible for the difference seen in fitting time, the outliers were removed, and the statistical test was run again.

Mann-Whitney U tests were also conducted to determine whether the qualitative ranking given to crowns at the time of delivery differed between the digital and conventional categories.
RESULTS

Eighteen implant crowns were analyzed for this study, with 9 in each group. The conventional group contained 7 males and 2 females, with an average age (± SD) of 46.6 (± 18.4) years. The digital impression group contained 6 males and 3 females, with an average age (± SD) of 42.4 (± 19.2) years. The conventional impression group contained 7 posterior and 2 anterior restorations, while the digital impression group contained 5 anterior and 4 posterior restorations.

The average time to insert a crown manufactured from a digital impression was 120 ± 46 sec. The averaged time to insert a crown in the conventional impression group was 401 ± 334 sec. Removing two outliers, the average time to insert a crown in the conventional impression group was 243 ± 130 sec. Time for insertion was significantly different for digital impression and conventional impression groups (p < 0.01).

The average qualitative score for crowns made using a digital technique was 3.1 ± 0.6. The average qualitative score for crowns made using conventional impression technique was less at 2.67 ± 0.7. Although the trend was toward significance, these scores were not significantly different (p = 0.15).

In the conventional group, 5 crowns required occlusal adjustments. In the digital impression group, only one crown required occlusal adjustments. All crowns had appropriate occlusion following insertion. Stated differently, no crowns were out of occlusion.

DISCUSSION

This scanning technology examined in this paper has its origins in laboratory processes used to fabricate CAD/CAM abutments. Typically, a clinician might make a conventional implant impression and send it to the lab for a CAD/CAM abutment and crown. To fabricate the abutment, the lab places a scan abutment on the traditional cast, and scans the cast to create a digital working model. The abutment and crown can then be designed, milled, and seated on the physical cast. It was a small, but innovative step, to move the same scan abutment to the mouth, scan in the mouth, and go directly to the design phase with no physical cast.

In this study, the performance of digital impression techniques compared favorably to conventional techniques. The lower time
Figures 7-9: Final crown is inserted. Minimal adjustment was needed to place the crown clinically. Appropriate clinical contours are obtained.

For insertion for the crowns made with digital impressions may reflect greater precision of the technique. They simply fit better, especially in regard to occlusal and proximal adjustments. Most of the crowns fabricated using a digital impression went to place with no adjustments at all. This was something of a surprise to the authors, who considered that the digital technique might produce similar crowns, but not better crowns, than the conventional techniques. These findings are similar to an in vitro analysis of digital impressions for implant impressions which documents an accuracy of 55 µm (± 21.8) for conventional techniques, compared to 49 µm (± 14) for casts produced with digital impressions. The authors conclude that accuracy of both methods is similar.

These results contrast to one study that found digital impression techniques were less accurate than traditional techniques. However, in this study the healing abutment was scanned, rather than a scan abutment, which may produce more errors. The longer standard impression coping used in our study may provide more surface area and greater length, leading to increased precision. While little is published on the clinical efficacy of digital impressions for implant crowns, may studies examine digi-
tal impression accuracy for casts and natural teeth, especially when considering in vitro studies. Kim et al. determined digital impressions differed from originals by 17.6 um (± 45.6), while conventional techniques produced casts were accurate to within 23.9 um (± 17.6). One clinical study found the marginal gap for crowns produced with digital impressions to be 130 um on the midaxial location, which the authors concluded was an acceptable clinical outcome.11 Another in vitro analysis found marginal discrepancies of about 50 um, and also concluded that these values compared well to conventional techniques.12 Several other articles find that digital impressions produce casts, crowns, and clinical outcomes which compare favorably to conventional impressions.13-19

Digital impression techniques offer some efficiency advantages compared to conventional techniques. Because digital files are sent electronically, the clinician saves on shipping costs. Also, most laboratories offer reduced fees for digital impression cases as the cost of production is lower because no cast is poured or physically articulated. Digital impressions take less time for beginning clinicians,7 and may offer some esthetic outcome advantages.20, 21

While a difference in seating time was evident in these data, the qualitative assessment was not significantly different. This may be due to the favorable clinical situation associated with the custom milled CAD/CAM abutments. Generally, these abutments facilitated quick and easy crown insertion by effectively correcting angulation and position irregularities, and by placing an ideal finish line at the crest of tissue. With a favorable foundation, the overall restoration was evaluated positively in many cases.

All restorations were deemed clinically acceptable. Two restorations, both in the conventional impression group, required significant occlusal adjustment to achieve harmonious contacts. While the reason for this was not apparent, it is possible that the centric jaw relationship or mounting was incorrect, leading to inaccuracies in the final restoration.

CONCLUSIONS
Single-implant crowns produced with optical impressions took significantly less time to seat clinically than crowns produced by conventional techniques. Both techniques produced clinically acceptable restorations.

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Background: Diagnosis and relief of the symptomatology and dysfunction in the temporomandibular joint (TMJ) and associated orofacial musculature, known generally as Temporomandibular Disorder (TMD), continues to be the concern of dental and medical professionals. This critical report paints TMD as an insidious malady with a myriad of symptoms, both somatic and psychological. This psychological symptomatology of TMD is usually expressed as belonging to one of the affective (mood) disorders (e.g., depression or bipolar disorder). Furthermore, the psychogenic symptoms of TMD may undergo somatization, the process of conversion of mental symptomology into physical symptomology.

Methods: A demonstrative model of the symptomatic course of TMD running alongside that of bipolar disorder is presented. Treatment modes of the disorder are based upon an understanding of the far reaching manifestations and interactions of mental and somatic disorders and are presented in a flow chart of TMD therapy

Results: TMD symptomatology and underlying psychopathology are closely interrelated and often clinically indistinguishable. Psychopathology and subsequent somatization impacting TMJ function are generally expressed as increased risk of pain related disability, poor treatment outcome, increased health care utilization, and potentially iatrogenic treatment. A multi-disciplinary approach of accessing both somatic and psychogenic symptomology in formulating a treatment plan for TMD serves the best health interests and wellbeing of the patient.

Conclusions: TMD and affective disorders are interactional and dynamic conditions, involving triggering points, predisposers, and buffering components in psychological and somatic pain progression. However, psychopathology may run an insidious, background course of expression alongside TMD symptomatology. Exploration of the interface of psychological and physical factors of TMD is the key to determining the severity of the overall clinical condition of the patient and the subsequent pathways of treatment.

KEY WORDS: Temporomandibular Disorder (TMD), Affective Disorders, Psychopathology

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INTRODUCTION
This critical review describes the implications of the diagnosis of psychopathology in conjunction with Temporomandibular Disorder (TMD) as to symptomatology and clinical treatment modes. There appears to be a “duel diagnosis” of psychiatric factors that coexist with physical symptoms of TMD. Early studies (i.e., circa 1990) of this “duel diagnosis” did not conclusively reveal the connection between psychiatric disorders and TMJ dysfunction or orofacial pain. However, further studies revealed that the diagnosis of TMD often includes an underlying chronic mental disorder.

Among individuals seeking treatment for TMD, pain is the most common symptom. Psychiatric symptomatology may predominate in the TMD patient and be masked by pain or functional dystrophy of the temporomandibular joint (TMJ). Psychopathology, chronic pain, and dysfunction can run an insidious course and background milieu of expression in the life of the TMD patient. Therapeutic models of the confluent symptom-
atrologies in formulating a comprehensive and ongoing treatment plan are based upon an understanding of the far-reaching manifestations, adaptations, and interactions of these disorders.

As defined in the literature, temporomandibular disorder (TMD) is a heterogeneous set of clinical conditions characterized by pain in the masticatory and related muscles of the head and neck, and in the temporomandibular joint itself. Physical symptoms include limitations in function such as restricted ability to undergo lateral and/or protrusive jaw excursions, difficulty opening or closing of the mouth, occlusal disharmony, and/or the presence of clicking, popping, or grating sounds in the temporomandibular joint. Figure 1 presents a timeline comparing the early symptoms of TMD to the development of a threshold and onto chronicity characterized by depression or bipolar disorder and co-occurring physical symptoms.

Psychopathology may run an insidious, background course of expression alongside TMD symptomatology. In the cited literature, chronic pain patients with depression are classified by four levels, i.e., levels 1 through 4 with increasing intensity of pain and disability. In this studied population, as the pain intensity and disability level increase, the type of pain (e.g., back, headache, TMD) appears to follow a similar epidemiological course. Earlier studies by the same author classify TMD pain on three axes, i.e., severity of the pain, persistence of the pain, and impact on functional behavior and disability. In addition to pain, the symptomatology of TMD includes occlusal disharmony, limited range of motion of the jaw, and subluxation of the TMJ (i.e., the jaw gets locked upon opening or closing). Although TMD patients report a plethora of heterogeneous symptoms, the one unifying symptom that permeates all their lives is pain. TMD should be assessed and managed as a biopsychosocial determined condition.

**METHODOLOGY**

A model of the symptomatic course of TMD running alongside that of bipolar disorder is described in Figure 1. Proposed treatment modes are based upon an understanding of the far-reaching manifestations and interactions of these disorders (Figure 2).

Methods for management of TMD are derived from the arenas of treatment of behavioral medicine and health psychology. Psychosocial factors and their effect on cognitive, emotive, and behavioral activity highly impact the well-being of patients with long-standing pain and subsequently are key elements to be considered in the diagnosis and treatment planning of TMD.

Survey research, in conjunction with structured or unstructured interviews, is often employed in assessing and diagnosing both psychogenic conditions and TMD symptomatology. Biopsychosocial instruments used in the assessment and diagnosis of mental status and/or pain in the TMD patient include the following:

- **Beck Depression Inventory (BDI) and Beck Anxiety Inventory (BAI):** These are “pen and pencil” questionnaires that the patient fills out at each visit (taking about five-to-ten minutes to complete).
- **Minnesota Multiphasic Personality Inventory (MMPI):** The MMPI (the classic instrument in this area of assessment) is widely used in psychological research and evaluation. It contains self-report instruments and a depression scale.
Table 2: Flow Chart of TMD Therapy

- Mental Health Consultation
  - Psycho-(talk) therapy
  - Psycho-Pharmacotherapeutics

- Biofeedback
  - Relaxation Therapy
  - Stress Management
  - Cognitive Behavioral Therapy
  - Acupuncture

- Physical Therapy
  - TMJ/Muscular Manipulation
  - Thermal
  - Electro-Therapy
  - Skeletal Muscle Relaxation

- Pharmacological Intervention
  - Analgesia (NSAIDS, Acetaminophen)
  - Anti-inflammatory
  - (NSAIDS; Steroids)

- Removable Splint Therapy
  - Occlusal Adjustment
  - Open the Bite
  - Vertical Dimension
  - Balance Occlusion
  - Stabilize Oral

Adaptive Responses to Multi-dimensional Therapy
(In terms of decrease in TMD symptomatology and decrease in somatization of concurrent mental illness):
- Lowered Pain Intensity (most pronounced effect)
- Increased Function of TMJ and Supporting Musculature
- Change in Psychogenic Parameters:
  1) Decreased Depressive Symptomatology
  2) Decreased Hypomanic/Manic Activity
  3) Increased Coping Skills
  4) Decreased Negative Thoughts
  5) Improved Psychosocial Behavior
Research Diagnostic Criteria for TMD Examination and History (RDC/TMD): The instrument is the “gold standard” in history taking and diagnosis of both TMD and somatic conditions.

REVIEW OF THE LITERATURE
Many psychological, physical, and socio-behavioral factors appear to be predictors of TMD.18,19 Early TMD involvement may be associated with the psychological symptoms of mild-moderate anxiety and/or migraine headache.18 Early physical symptoms are generally minor and may present as joint clicking, popping, or grating of the TMJ.19 Advanced TMD patients usually present with significantly more affective (mood) disorders.20 These patients generally see life as very stressful, and subsequently employ nonadaptive coping mechanisms such as neurotic or obsessive-compulsive behavior.21 Psychopathology in the form of anxiety and depression is more prevalent in TMD patients with muscular diagnoses (i.e., myofacial pain, myositis, or myalgia) when compared to those with internal structural derangements of the TMJ (chronic joint or articular disc pathology).22,23 Considerable psychopathology is usually associated with TMD—a significant concurrent relationship exists between physical and psychological diagnoses.21

DISCUSSION
Somatization is defined by the American Psychiatric Association as the process of conversion of mental states into bodily or physical symptoms.24 The somatization hypothesis links multiple pain symptoms to the somatic expression of psychiatric and psychosocial functioning.22 Psychological stressors displayed as physical symptoms or as pain may result in negative behavioral phenomena such as social distress or occupational disability.25 Risks of somatization impacting the function of the TMJ are generally accompanied by the following conditions:24,25

1) Increased risk of developing pain.
2) Increased risk for extended duration of pain.
3) Increased risk of pain-related disability.
4) Increased risk for poor treatment outcome.
5) Increased health care seeking and utilization.
6) Risk of excessive, potentially iatrogenic, treatment.

Epidemiologically, the most common psychological variables associated with TMD are depression, somatization, and anxiety.26 However, associating somatization with numerous self-reported TMD symptoms may misdirect diagnosis of an underlying psychological etiology. Bio-psycho-social models of chronic pain can be applied to symptoms associated with TMD.13 Models suggest that physiologic, psychologic, and social factors may interact in different ways in TMD—expressing pain or in developing pain-related dysfunction.13 Bio-psycho-social interventions (e.g., pharmacotherapy, psychotherapy, counseling/mentoring) may improve adverse symptomatology in TMD with the following clinical outcomes:13

- Increased ability to control pain.
- Decreased disease-related beliefs and increased generalized coping.
- General decrease in both psychiatric and somatic disability.
- Improved coping skills for generalized symptomatology.
- Improved coping skills for depression or hypomania.
Decrease in physical symptoms (e.g., decreased frequency of subluxation, increased range of motion of the jaw).

The presence of multiple and chronic pain sites and/or symptoms are associated with elevated levels of anxiety and depression, lower self-esteem, along with increased physical symptomatology. Furthermore, co-occurrence of pain symptoms at more than one body site is significantly associated with major depressive disorder. Chronic pain symptoms are associated with three main conditions: poor self-appraisal of health status, increased use of pain medications, and increased incidence of psychogenic disorders.

Medical policies of major insurance companies often provide coverage for TMD therapy and generally recognize the following treatment modalities and their multidisciplinary applications (Figure 2):

- Intraoral splint therapy with reversible appliances and subsequent occlusal adjustment generally balance the occlusion, and stabilize the oral apparatus.
- Pharmacological treatment of TMD is largely symptomatic and nonspecific.
- Pharmacological interventions largely employ medications such as non-steroidal anti-inflammatory drugs (NSAIDs) and non-narcotic analgesic drugs.
- Physical therapy for TMD consists mostly of thermal modalities and jaw manipulation procedures.
- Biofeedback, acupuncture, relaxation therapy, and stress management are alternative therapies.
- Cognitive Behavioral Therapy provides adaptation skills by changing how we think as opposed to what we think.

No discussion of the confluence of mental disorders and TMD is complete without looking at the possible genetic ramifications of both TMD and affective disorders. Both disorders appear to be linked to genetic dysfunction or hereditary structural anomalies in cellular DNA. The relatively recent mapping of the human genome has lead to a subsequent “knowledge expansion” about both somatic and mental maladies of the human condition. In the future, such genetic knowledge may play the key part in determining the interrelationships, treatment modes, and prevention strategies for both TMD and affective disorders—especially when these disorders occur concurrently.

CONCLUSIONS

Chronic pain in TMD, be it of myofacial, arthralgia, or myofacial with arthralgia in origin can be graded on three axes: 1) the severity of the pain, 2) the persistence of the pain, and 3) the impact on functional behavior. The development of chronic joint or orofacial muscular pain can be characterized as conditions that are comorbid in susceptible epidemiological subgroups such as demographic (e.g., females; advanced age), post-traumatic (e.g., after extraction of 3rd molars; head injury), or psychiatric manifestations (i.e., anxiety, depression).

Patients with TMD may go for years with popping, clicking, and grating in their TMJ and totally ignore the symptoms of their condition. This symptomatology can be translated into myofacial pain exhibiting as hypersensitivity or dysfunction during mastication. Usually a strong life stressor precipitates a pathological oral/facial situation—pushing the patient “over the threshold” into painful symptomatology and subsequent dysfunction. How-
ever, as the life stressors subside, so may pain and dysfunction. Pain is the general focus of TMD morbidity—with mental and functional symptomatology as comorbidity. With the advances in genetic studies occurring with the mapping of the human genome and present DNA research, the future looks bright for not only treatment of TMD and affective disorders, but for a cure for these maladies.

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Oralife is a single donor grafting product processed in accordance with AATB standards as well as state and federal regulations (FDA and the states of Florida, California, Maryland and New York). Oralife allografts are processed by LifeLink Tissue Bank and distributed by Exactech Inc.

1. Data on file at Exactech.