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Date: 05/14/2014

A COMPARATIVE ANALYSIS OF MARGINAL GAP

CEREC AC BLUECAM inEOS versus CEREC AC OMNICAM

BY

MICHAEL ROBERT VILLACARLOS, DDS

A THESIS

Submitted in partial fulfillment of the requirements
for the degree of Masters of Science in the
Department of Oral Biology
In the Graduate School of
The Uniformed Services University of Health Sciences

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2014

Submitted by Michael Robert Villacarlos in partial fulfillment of the requirements or the degree of Master of Science specializing in Oral Biology.
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LIST OF ABBREVIATIONS

AC – Acquisition Center

ARC – Adhesive Resin Cement

CAD – Computer Aided Design

CAM – Computer Aided Manufacture

CEREC - Chairside Economical Restoration of Esthetic Ceramics

CEREC XL – milling unit

MI – Maximum Intercuspation

STL - Stereolithography

2D – two dimensional

3D – three dimensional

ABSTRACT

Objective: To evaluate if there is a statistical difference in marginal gap between the use of the CEREC AC BLUECAM inEOS by SIRONA with Optispray versus the CEREC AC OMNICAM by SIRONA. Specifically, with the use of a typodont model of tooth #19, each machine was used to prepare an ACC and were examined against the gold standard of 39microns using CEREC 4 software.

Materials and Methods: Marginal gap determination was examined after prepared crowns were scanned using either the CEREC AC OMNICAM (Sirona Dental Systems, Charlotte, NC) or CEREC AC BLUECAM inEOS (Sirona Dental Systems, Charlotte, NC). Milling parameters for margin thickness were the same for both the CEREC AC BLUECAM inEOS and CEREC AC OMNICAM utilizing the CEREC MC XL Premium milling unit to fabricate the all ceramic crown (ACC). A Columbia Dentoform (Long Island City, NY) model T-1560 with a full complement of thirty-two (32) ivorine teeth was utilized to conduct the table top study. Specifically tooth #19 – Columbia Dentoform Ivorine tooth (Long Island City, NY) was prepared at a 4-6◦ tapered angle with 1.5mm occlusal reduction. After cementation of crowns, they were imaged with a SteREO Discovery. V20 stereomicroscope and measured readings of marginal gaps were denoted from eight specified locations circumferentially. Means, standard deviations, and variances were calculated for all specimens. A student t-test was performed between the two sets of averages between CEREC AC BLUECAM inEOS and CEREC AC OMNICAM .

Results: Variances between CEREC AC BLUECAM and CEREC AC OMNICAM proved to be very different (BLUECAM variance = 9.68; OMNICAM variance = 26.37). A "t-test" value of $p=0.02$ found a statistical difference exists between the mean marginal gaps of two groups tested.

Conclusion: This study found that there is a statistical difference between the mean marginal gaps of CEREC AC BLUECAM inEOS when used with TiO_2 (Optispray) versus CEREC AC OMNICAM. However, the data did not account for variation in the methods of preparation of the specimens, and had various outliers in the data collection producing unequal variances found between the two test groups. Therefore, a firm conclusion on which machine would produce a true statistical difference.

Introduction

A. Statement of Problem

The importance of marginal adaptation for a CAD/ CAM crown plays a large role in its success in terms of longevity and means for prevention of plaque retention. Specifically, marginal adaptation can be evaluated after thermomechanical loading at the crown to luting cement surface. Poor marginal adaptation of CAD/ CAM dental restorations may increase the retention of plaque leading to the inflammation of surrounding periodontal tissue and become a source for caries or secondary caries.[17, 47, 57]

The specific location on the crown that is of interest is the marginal gap. Marginal gap is the distance from the internal surface of the restoration to the axial wall of the preparation along the margin. [3]

B. Significance of Marginal Gap

Traditionally, single crowns are processed over the course of days or weeks at an off-site dental laboratory, as patients would wear dental temporary restoration(s) while waiting for the final step of bonding or luting the final prosthesis. However, with CAD/CAM technology, restorations are placed in same day appointment. CAD/CAM systems have a large niche in fixed prosthodontics dentistry ranging from onlays, inlays, partial crowns, veneers, and crowns both the posterior and the anterior region. [21] The process of fabricating restorations involves the use of single monolithic blocks made from various materials such as zirconium-oxide (zirconia), lithium-disilicate, and feldspathic. [36, 37, 44] Images are captured with an acquisition unit and formulated into STLs files. STL or stereolithography acts as a means for representations of three dimensional forms as boundary representation solid models constructed entirely of triangular facets defined with just three points and an orientation vector. These STL files help to describe a closed, unambiguous solid as they are sent to an onsite milling center for fabrication of the dental restoration. [32, 33, 34, 49, 50, 52, 58]

I. Review of Literature

A. History of CAD/CAM technology

CAD/CAM stands for "computer aided design" / computer aided manufacture. CAD/CAM had previously been in use over 25 years prior to its use in dentistry. In the 1960s, CAD/CAM was used in the automobile and aircraft manufacturing industries. [10] This mass production of vehicles and aircraft would later be applied to the production of restoration in dentistry. By the 1970s, Dr. Francois Duret of France developed the first CAD/CAM device for use in dentistry. With further research and development, Dr. Duret went on to fabricate the first dental restoration with his version of the CAD/CAM in 1983. Later, he would showcase the first dental CAD/CAM device in 1985 at the French Dental Association's international congress, using his wife as a live patient for fabrication of a crown. His CAD/CAM device would be known as the Sopha system. [12, 15]

Yet, it was Dr. Werner Mormann of Switzerland who developed the first commercially bought CAD/CAM. He would partner with electrical engineer Dr. Marco Brandestini, using an optical scanner for acquisition of images of prepared teeth. [10,12, 15, 56] The same year (1985) that Dr. Duret had showcased his CAD/CAM system, Dr. Mormann and Dr. Brandestini had developed CEREC = computer assisted ceramic reconstruction. Also notable at this time of CAD/CAM technology involved Dr. Dianne Rekow of the USA, who utilized photographs and a high resolution scanner to mill restorations, and Dr. Matts Andresson of Sweden who was credited with being the first person to fabricate composite veneered restorations with the use of CAD/CAM. [10, 12, 15]

B. Dental Office - CAD/CAM overview

The ability to produce a tooth-colored dental restoration is achieved with the use of a "chair side" CAD/CAM dental digital device. [56, 58] A dental patient's tooth is first prepared for a crown, followed by acquisition of an optical impression of the prepared tooth site and surrounding dentition. The CAD/ CAM device typically consists of an acquisition device that is handheld. This acquisition device is placed intra orally to capture the prepared tooth and surrounding dentition, producing a computer screen image in 2D or 3D. The computer screen image lends itself to the design work which will be done to include internal fit, contact, and contours of the restoration to be fabricated. [15, 16, 23]

With this information, computer software is then used to create a virtual restoration. All of the data acquired from the computer software along with the acquired images of the prepared tooth site are then sent wirelessly to either an onsite or offsite milling center where the restoration will be fabricated from a monolithic block of ceramic in this case either zirconium-oxide (zirconia) or lithium-disilicate.

C. Advantages/ Disadvantages of CAD/CAM vs. Traditional Impressions

With an aging world population there will be a continued need for restoring teeth with the use of indirect restorations such as crown, fixed denture prosthesis, veneers, and inlays in multiple visits. Traditionally, a dentist first prepares the tooth site for a particular restoration, take an impression (negative) of the teeth (positive), and then fabricate an interim restoration, while the dentist sends off the impression to the lab for fabrication. The finished restoration is sent back to the dentist within 3-5 business days and then is definitively cemented into the patient's mouth.[18, 20, 21]

However, with the use of CEREC, a patient can have a milled dental restoration placed within one visit. Overall the use of digital scans prove to be faster and easier than compared to traditional alginate impressions because of the time involved with casting, wax-ups, investing, and firing. Essentially man hours are eliminated in the CAD/ CAM optical impression process, producing savings in time and labor and reducing costs. (Table 1 [55]) Top market competitors in the CAD/CAM arena boast claims that arch impressions with the most recent version of CEREC take 40 seconds to a few minutes. Along with milling time of up to 10 minutes, it is possible to fabricate and cement a dental restoration in one dental visit, while producing a high quality dental restoration and avoiding the need to take traditional alginate impressions. [21, 48]

Comparison of traditional work flow with digital work flow.

WORK-FLOW STEP	TRADITIONAL WORK FLOW	DIGITAL WORK FLOW
Taking Impressions	10 minutes per arch	Two minutes per arch (Figure 1)
Filling Out Laboratory Prescription	Handwritten	Digital prescription entered on screen (Figure 2)
Submitting Case to Laboratory	Courier, one to three days	Electronic portal, 10 seconds
Designing and Fabricating a Full-Contour Restoration or Framework, if Required*	Must wait for model work, additional day	Completed from digital model
Fabricating Model*	Die stone, sectioning, with potential for error	Stereolithography models built overnight during framework creation
Finishing Restoration	Work flow varies according to the selected materials (for example, monolithic or polylithic materials)	Work flow varies according to the selected materials (for example, monolithic or polylithic materials)

* This step is not necessary for computer-aided design/computer-aided manufacturing production of monolithic restorations.

Table 1: Comparison of traditional work flow with digital work flow.

Moreover, other laboratory tests done by practitioners noted problems encountered when taking traditional alginate impressions. Nearly 50% of the prep margins were found to not be discernible as traditional impressions may present with: blebs, bubbles, tears, cord, or other debris in the impression material. [5, 22, 58, 59]

Practitioners have often sited that the disadvantages come in the form of monetary means to acquire a CAD/CAM device. The initial startup comes in the form of purchasing the device along with class training for everyone that will be utilizing the device. Other disadvantages lay in the type of CAD/CAM device that is purchased to do the optical scan. When taking the optical impression of the prepared tooth to be restored the practitioner still needs to abide by the same rules of soft tissue management (i.e. hemostasis, tissue retraction, moisture control). Overall, optical impressions need to produce an accurate reproduction of the actual tooth to be restored along with the surrounding dentition (i.e. adjacent and occlusive teeth). [5, 22, 58, 59]

D. Available CAD/CAM Technology for the Dental Practitioner

A review of popular products on the market for dental office use include CEREC AC, E4D, iTero, and Lava COS. [10, 42] The ability to save on high monetary overhead cost acts as the impetus for moving towards optical impressions, as there is no longer any need for impression materials to include impression trays, cleanup/disinfection involved with dental impressions, and use of an off-site laboratory. [13, 56, 60]

The oldest and first system since 1987 is the CEREC by Sirona. CEREC AC (2009) is an all in one on-site dental office product. With the CEREC AC, the dental practitioner can acquire, design and mill the dental restoration in the convenience of their office. Depending on which CEREC AC system used, an opaque medium (i.e. TiO_2 – Optispray by Sirona) [23, 25] is utilized on teeth with translucent areas in order to register all tooth surfaces that are scanned with the optical scanner, such as with the CEREC AC BLUECAM (Figure 2). [25, 27, 28] BLUECAM utilizes an LED sensor to capture images of the tooth/teeth to be restored. Images are monochromatic, as the BLUECAM utilizes blue LED technology. [3, 16, 23,42]

Sirona's newest model is the CEREC AC OMNICAM, which utilizes no spray and takes optical scan images directly from the mouth of the patient (Figure 1). The color display utilizes white LED light and can capture a wider spectrum of data with streaming capability. For the dental practitioner this means the ability to capture images in streaming view, creating a full contrast colored image. With both products, several optical impressions are then taken to include from 1) an occlusal orientation of the tooth prepared, 2) an occlusal orientation of the opposing arch, 3) a buccal maximum intercuspation orientation on the side that is being restored. [10]

E4D (2008) is similar to the CEREC AC with acquisition, design and milling. The D4D Technology Co. allows for the dental practitioner to buy the unit in pieces, meaning they can separately purchase the design center/laser scanner or the milling unit separately. The difference between E4D and CEREC AC is in the manner in which image acquisition is done. There is the option to utilize a powder for image acquisition. In addition the need for taking a scanned image of the opposing arch is instead done with the use of an occlusal registration which is then placed on top of the tooth to be restored. [10, 12]

Cadent iTero does not use powder. This machine relies solely on the use of 100,000 red laser beams focused on the surface of the tooth to be restored. The light that is reflected back from the tooth to be prepared is then transformed into data that is converted into a 3D rendering, which the dental practitioner can review. The iTero will provide voice and visual commands to guide the dental practitioner as to which images need to be acquired. There are certain drawbacks seen with the iTero. Along with the time needed to capture images, a drawback with this machine is that anywhere from 15 to 30 images need to be taken, as well as the need to place a bulky scanner into the patient's mouth. Milling of the dental restoration is sent to an off-site dental laboratory for fabrication. [10, 12]

LAVA Chairside Oral Scanner obtains images are acquired with the use of 192 LED lights and 22 lens system, as images are captured at video rate. [10, 12] When the dental practitioner has finished their preparation, TiO2 is then placed into the prepared arch where the intra oral scanner will be used. Four images are taken to include the buccal, lingual, and 2 renderings of the occlusal surface. Upon approval, images will then be sent to a laboratory and then finally to 3M for fabrication of a stone model which is then sent back to the lab for the final fabrication of the dental restoration.

E. Accuracy – Trueness and Precision

Scanning of the surfaces of the teeth in the patient's mouth (i.e. digital impression) is done optically and directly. This creation of virtual models of the patient's teeth serves as the basis for the design and milling of the restoration. However, the manner in which the virtual model is attained often raises the question of accuracy of the intraoral digital impression. Therefore, the accuracy of a digital impression can be described in terms of both trueness and precision. [16, 17]

Trueness is the comparison of the reproduced object to that of the actual reference model as it deviates from the true size of the object. Precision describes how closely measurements are grouped together along with how much they fluctuate from the actual object that was measured. A way to describe trueness and precision can be seen in target shooting at a range. The trueness in target shooting would be how close one's shot would be to the bullseye of a target; while the precision would be determined by how close shots are grouped together. Trueness can be measured in one of two ways. The first way involves points that are measured or defined on a reference model using linear distance measurements. These measurements from the reference model are then compared to the test subject. [16,17]

The second manner in which to test trueness is through the use of superimposing a scanned surface of a model to the test subject which will test for three dimensional trueness. Precision is attained with the number of test subjects taken and then compared to how close they are to one another. [16, 17]

F. Marginal Adaptation – Dental Restoration

CEREC technology utilizes CAD/CAM in dental clinical use to fabricate dental restorations from machinable ceramic blocks. The marginal and internal adaptation of the milled dental restoration becomes critical in minimizing subsequent marginal ditching or wear of the luting resin. Thus, the existence of marginal discrepancies in a dental restoration may expose the luting resin to the perils of the oral environment, leading to a loss of bonding or an incomplete bond. The loss of integrity of the marginal adaptation leads to an attack of the vital pulp with entrance of food particles, bacteria, and oral debris.[26]

G. Significance of Marginal Gap in the Evaluation of Fit for Complete Crowns

A major production requirement of CAD/CAM dental restorations is the accuracy of fit in terms of long-term survival. Long term survival translates to success for both the dental practitioner and the patient but more importantly is tangibly seen as whether or not the dental restoration prevents the retention of plaque. [17, 27, 29, 33, 35, 36, 38, 46, 47, 51, 53] Therefore, having a good fit means minimizing marginal gap within an acceptable range of 30-200µm, which is achieved with the (1) accuracy of the CAD/CAM system utilized and (2) controlling the 3D sintering of the dental restoration. [6] According to manufacturer recommendations final processing of zirconia in a presintered state into a sintered state is necessary to complete the final dimension of the restoration after it is machined. [6, 59]

II. Purpose

The objective of this study is to analyze and compare the marginal gap of milled all ceramic crowns when using either the CEREC AC Bluecam or the CEREC AC Omnicam. CEREC AC Bluecam involves the use of LED technology along with the use of an opaquer spray (CEREC Optispray) for image acquisition. [23, 25,27, 28] CEREC AC Omnicam acquires images directly from the patient's mouth and does not require the use of an opaquer spray.

III. Null Hypothesis

There is no statistically significant difference in the marginal gap measurements made from scanning a dentoform typodont with the CEREC AC BLUCAM when compared to scanning a dentoform typodont with the CEREC AC OMNICAM when milling an all ceramic crown (ACC). The alternative hypothesis states that there is a statistically significant difference in the marginal gap measurements made from scanning optical impressions with the CEREC AC BLUECAM when compared to scanning optical impression with the CEREC AC OMNICAM when milling an ACC. We expect the CEREC AC OMNICAM to have a more favorable and smaller marginal gap, being that it is the newest machine from SIRONA.

SPECIFIC AIMS/ SIGNIFICANCE

This study aims to measure and compare the mean marginal gap between CEREC AC BLUECAM and CEREC AC OMNICAM and to determine and statistical difference.

MATERIALS AND METHODS

A. Overview

A Columbia Dentoform (Long Island City, NY) model T-1560 with a full complement of thirty-two (32) ivorine teeth was utilized to conduct the table top study. Specifically tooth #19 – Columbia Dentoform Ivorine tooth (Long Island City, NY) was prepared unscrewed out of the typodont by hand at a 4-6◦ tapered angle with a 1.5mm occlusal reduction with a chamfer burr and high speed handpiece (Figure 6 and 7). Crowns were then screwed back into the typodont and then imaged.

B. OMNICAM – Specimens 1-15

For the OMNICAM, specimens 1-15 were prepared sequentially and imaged immediately following the conclusion of each preparation. CEREC 4 software was utilized to image the prepared typodont teeth for the OMNICAM test group (Figure 10) OMNICAM specimens were milled with their own corresponding CEREC XL milling unit denoted as milling unit #1. Milling parameters for margin thickness were the same for both testing groups: OMNICAM and BLUECAM inEOS with the prepared all ceramic crowns(ACC) (Figure 4 and 5). [48] IPS Empress CAD blocks – Multi A2 shade/ C14 size blocks were utilized for both test groups and did not require any further firing after crowns were milled (Figure 8).

C. BLUECAM – Specimens 1-15

For the BLUECAM inEOS, specimens 1-15 were prepared sequentially and imaged immediately following the conclusion of each preparation. The BLUECAM study differed from the OMNICAM study, in that the BLUECAM utilized an opaque spray to image the specimens (Figure 9). CEREC 4 software was utilized to image the prepared typodont teeth for the

BLUECAM inEOS test group (Figure 11). BLUECAM inEOS specimens were prepared on a separate corresponding CEREC XL milling unit denoted as milling unit #2. Milling parameters for margin thickness were the same for both testing groups: BLUECAM inEOS and OMNICAM with the prepared all ceramic crowns(ACC) (Figure 4 and 5). [48] IPS Empress CAD blocks – Multi A2 shade/ C14 size blocks were utilized for both test groups and did not require any further firing after crowns were milled (Figure 8).

D. CEREC MC XL – milling unit

Maintenance of the CEREC MC XL Premium milling units were done accordingly, when prompted to do so by caution screen on machine, such as changing of burrs, filters, and fluids (Figure 3). Lastly, marginal fit for the entire lot of ACCs were checked with a magnifier prior to cementation and were minimally adjusted with the use of a blunt diamond bur after shown with an indicator OCCLUDE spray (Pascal Co INC, Bellevue, WA).

E. Cementation

Next the ACC was painted with a nail varnish (clear) (OPI, N. Hollywood, CA) 2mm below the restoration margins. The all ceramic crowns were then cemented using the NEXUS3 - Adhesive Resin Cement (Kerr, Orange, CA) (Figure 12). Each ACC (all ceramic crown) received resin cement from the dispenser according to manufacturer's recommendation for ACCs, and was applied to the typodont tooth in the articulated model. The axial loading pressure for all crowns was seated with thumb finger pressure for an amount of time (60seconds) denoted by the use of a stopwatch done at room temperature and excess cement will be gently removed. [36] Tach curing done in 1 second intervals to remove excess cement, while polymerization of the luting agent was performed with a curing light from the buccal, lingual, and proximal surfaces for 20 seconds at each aspect. To make the resin cement in the marginal gap between the model ivorine tooth substance and the ACC clearly visible, specimens were hand painted with caries indicator solution and were set to dry for a period of 24 hours. [26]

F. Stereomicroscope

Marginal gap determination was examined after prepared crowns were scanned using either the OMNICAM or BLUECAM inEOS. The use of a stereomicroscope (SteREO Discovery. V20, Carl Zeiss, Tokyo, Japan) was used to measure marginal gap between the internal surface of the milled copings to the ivorine teeth models at eight preselected locations of the (mesial, mesial buccal line angle, mid-buccal, distal buccal line angle, distal, distal lingual line angle, mid-lingual, mesial lingual line angle) at 80x magnification (Figure 13). [26, 24, 53, 54] The stereoscope was calibrated and images were shown to have a scale of 100microns and was used for each of the images produced at each location giving a total of 24 readings per specimen 1-15 for both the CEREC AC BLUECAM and CEREC AC OMNICAM (Table 3 and 4). Random locations were picked to measure the shortest distance in microns between the ivorine tooth model margins and the milled ACC at the measuring points as described previously. [26] (Figure 15)

Utilitzing Microsoft EXCEL, these twenty-four (24) measurements were then averaged to give a numerical mean for each specimen 1-15 for each of the machines utilized in the study (Table 3 and 4). All means, standard deviations, variances were calculated for all specimens, as a student t-test was utilized to measure the statistical significance of the study, being that the comparison was between two sets of averages between CEREC AC BLUECAM and CEREC AC OMNICAM (Figure 18).

G. Statistical Analysis

A student T-test (2 sample t test) was used to compare between 2 independent-study groups (eg. Group 1 and Group 2) if data appeared normal distribution, verified with Shapiro-Wilk Test. However, in the event of two sample groups having unequal variances, a Welch's *t* test, an adaptation of Student's *t*-test will be utilized.

H. Sample Size and Power Determination:

Based on the desired power (1-beta) of 80%, the significance level of 5% (alpha), the expected within group standard deviation (SD) of 37um [37], and the expected clinically significant size difference of 40um between the 2 independent-study groups to be compared, given the tip of a new dental explorer is 70um, a sample size of 15 specimens per group was used (Table 2). [51, 53, 54]

Table 2. Single calculation: Sample size estimation for comparative analysis of two groups.

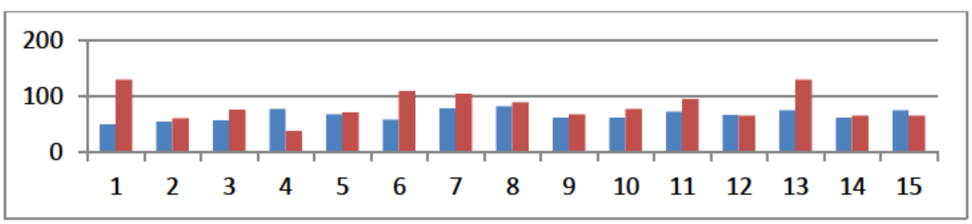
Single Calculation: Sample Size Estimation	
Probability of Type I Error (alpha)	0.05
Power (1-beta)	0.80
The difference between the 2 groups to be detected	40
The expected within group standard devivation (SD)	37
Sample Size required (per group)	15

Results

Variances between CEREC AC BLUECAM and CEREC AC OMNICAM proved to be very different (BLUECAM variance = 9.68; OMNICAM variance = 26.37) (Figure 5-6). Furthermore, because our null hypothesis had stated that there was no statistical difference between the two machines, the *student t-test* was chosen otherwise known as "two-tailed- t test". The *student t-test*, is an inferential statistical test that determines whether there is a statistically significant difference between the means in two unrelated groups.

Line graphs were produced for each of the machines to show the average means for both machines, as well as a box graph illustrating how each numerical specimen compared to its counterpart in the study (Figure 18/ Table 5 and 6). Differences were considered statistically significant at $p \leq 0.05$. A summary of results and significant statistics for marginal gap between the CEREC AC BLUECAM and CEREC AC OMNICAM can be seen in Figures 16-19.

Figure 18. Graphs showing overlay of OMNICAM (red)#1-15 & BLUECAM (blue) #1-15 vs. average marginal gaps on specimens.



BLUECAM	**Statistics**
AVG =	**67**
STDEV=	**9.684056608**
Variance =	**68**
OMNICAM	**Statistics**
AVG=	**82**
STDEV =	**26.37332707**
Variance =	**695**
t-test = 0.026	**p<0.05**

DISCUSSION

A. **INTERPRETATION OF DATA**

In retrospect, specimens could have been reproduced from only one ivorine die rather than preparing 30 such specimens by hand. In this way, there was no way to control for variation amongst all prepared specimens. Therefore, if such a die was reproduced thirty times more potential confounding variable would be introduced such as type of stone used to produce the specimens, mixing of the stone/ water ratio, expansion and contraction of stone, etc.

Moreover, the standardization of seating the milled ACCs onto the ivorine dies may have been better served with a device to control for a seating pressure of 20N rather than merely using digital finger pressure to seat the ACC. In addition, the need to "minor" adjust the ACC to fit the dies may have introduced variation in the marginal gap when measuring with the stereomicroscope.

In terms of the machine maintenance, the two CEREC XL milling units that were utilized could have been calibrated to the use of fresh burs at the start of the study. The changing of burs at every 5 specimen preparation may have resulted in a more favorable milled ACC and better fit to give a more favorable marginal gap.

However, the use of a typodont and ivorine teeth for this study proved to be very cost effective and easy. Giving to the design of a table top study, the manner in obtaining data became very systematic and efficient after learning how to utilize each of the two machines.

Data was obtained through the use of the SteREO Discovery. V20 stereomicroscope, measuring from the margin of the tooth to the surface of the ACC. Data was measured from random locations 360 degrees around the tooth cemented restoration in question, namely #19. Three measurements at each of the specified locations were determined to be mesial (M), mesial buccal line angle (MBLA), mid-buccal (mB), distal buccal line angle (DBLA), distal (D), distal lingual line angle (DLLA), mid-lingual (mL), and mesial lingual line angle (MLLA) for a total of twenty-four (24) measurements. Measurements were then averaged to give a mean, to which both machines were compared with a "*student t-test*". Statistical analysis showed that the variances among the two test groups were unequal, namely due to five of the fifteen specimens of the OMNICAM having outliers in the +100 micron range. When these outliers were not included, and new mathematical means were generated both the OMNICAM and BLUECAM studies proved to be nearly equal at approximately: mean = 67.

However, simple "*student t-test*" for the statistics on the measurements obtained on this study with inclusion of all measurements including outliers had a $p=0.02$, which is less than $p\leq0.05$. However, due to the aforementioned variations in data collection, lack of calibration of crown preparation and milling practices a firm conclusion to accept or reject the null hypothesis can not be firmly made. Based on the graphs and interpretation of the data, it would behoove us to think that the BLUECAM mean was equal to 67 and outperformed the OMNICAM with measurements either being at the gold standard of 70microns or lying at least 2 standard deviation ($\sigma = 9.68$)above or below the 39 microns measurement with a variance of approximately 68. With the inclusion of outliers in the data for OMNICAM the mean obtained was 82, while nearly 33% of the measurements were either 3 or 4 standard deviations (σ=26.37) off of the 39micron gold standard for marginal gap, with a variance of 695.

Therefore, data obtained for the BLUECAM inEOS was graphed on a line graph and showed to have a lower variance with means falling closer together for all specimens #1-15, being of both higher accuracy and high precision for the data set. However, the data obtained for the OMNICAM showed to be a larger variance with means falling anywhere from 2 to 4 standard deviations from the gold standard, being a lower accuracy and low precision for the data set. Moreover, only two of the fifteen (13%) of the specimens #1-15 taken from the OMNICAM measurements outperformed those of the BLUECAM measurements. For the BLUECAM measurements, almost thirteen of the fifteen specimens (87%) outperformed those of the OMNICAM measurements.

B. **RETESTING OF DATA**

Retesting of 25% of the specimens was not done in this study and may provide a source of bias and error. Limited availability of utilization of tools for measuring (i.e. stereomicroscope) did not fit into time constraints at off-location at DECS location in Ft. Sam Houston, Texas. The probability that one machine is far superior to the other can not be concluded based on the small sample size chosen and due to limitations from a financial and time standpoint.

C. **OMNICAM v. BLUECAM inEOS**

OMNICAM and BLUECAM both have a valuable use in the dental office. Speaking from experience, the OMNICAM seemed to have a learning curve that was not as steep as the BLUECAM. Moreover, OMNICAM could be utilized by the dental professional in a chairside manner, scanning the patient's mouth and utilizing directly the CEREC MC XL to mill out the ACC. However, for our study we chose to examine the use of BLUECAM inEOS similar to the chairside CEREC AC BLUECAM, only that this particular device for our study was that it is a lab bench machine utilized by the lab personnel to fabricate the ACC. This would have involved making an accurate impression of the prepared tooth, pouring a stone model, and waiting for full setting of the stone (i.e. CADSTONE – low expansion). It is then that the "creator" of the ACC on the BLUECAM inEOS would then go to the computer aided designing of the prosthesis and there is still a need for the use of Optispray in order to pick up a crisp and clean image. There is more time involved in the use of the CEREC AC BLUECAM inEOS and also proved to be very technique sensitive, having to lower and raise to focus the images created on the still camera.

In comparison to that of the OMNICAM images are taken as a streaming video with the computer returning audible sounds to let the user know if the image is being returned in a positive manner. It is what makes the OMNICAM a favorable tool to the dental practitioner in that it gives immediate feedback to the user both audibly through the sounds of "positive capture" and visually as the computer takes this "positive capture" and interprets it as a real time image of what exists in the patient's mouth that is being restored.

D. **OPERATOR ERROR**

Comparing one practitioner to another practitioner, the objective data that is obtained through each machine and the software that is utilized to interpret the data may be quite different. The speed and technique for which a practitioner obtains the data will further be utilized in interpreting margins, occlusion, intaglio, and contacts. This interpretation of data can be both objectively and subjectively interpreted differently from one practitioner to another producing one restoration different from another practioner's rendition of the same restoration.

In this particular study, both fatigue and efficiency may have played a role in the measurements that were achieved. The beginning of the study proved to be slow and inefficient with steep learning curves on both devices, while later becoming more efficient moving in a timely manner. This study sought to do the CEREC AC OMNICAM #1-15 first, followed by the CEREC AC BLUECAM #1-15, because of the use of the Optispray for the second half of the study which we did not want to influence the image acquisition on the CEREC AC OMNICAM study. Fatigue may have set in towards the end of the study having prepared all specimens and doing all measurements, with few breaks in between each of the study test data measurements for both machine's specimens thus influencing the types of measurements taken further into the study.

CONCLUSION

The present study can not definitively state whether the BLUECAM or the OMNICAM resulted in more minimal marginal gaps. This is in part due to the variations in the prepared ivorine specimens and the manner in which specimens were seated and adjusted to fit on the dies.

The idea of taking dental impressions was utilized from the 1800s to the early 1900s. By the 1920s the use of reversible hydrocolloids came onto the dental scene, and the advent of World War II saw the invention of irreversible hydrocolloids followed by polysulfides, polyethers in the 1960s, and polyvinyl silocones in the 1970s to present day.

With the invention of the use of CEREC, it managed to find its way from the airplane and automobile industry into the dental arena. Evolving over the course of almost nearly forty years of research, restorations now have the ability to be restored in lesser amounts of time and are becoming more and more affordable being within reach for every type of patient (of course never forgetting patient selection).

Further research may hold new leaps and bounds with the concept of making a dental impression. Perhaps in the future a reusable dental impression tray, that is equipped with sensors capable of making the impression requiring your assistant to simply place the tray in the patient's mouth and press a single button. Future studies may choose to examine the use of full laser scanning to image a tooth for a dental restoration. Otherwise, are those days of carving wax lost? I would argue no; only that your canvas for carving and recreating the finer points of a tooth are now on a computer screen with software for tools and a computer mouse to guide the artist's hands.

Figure 1. CEREC AC BLUECAM inEOS with TiO2 spray for imaging #19 on Typodont.

Figure 2. CEREC AC OMNICAM.

Figure 3. Closeup photo of CEREC MC XL Premium milling unit with CAD block.

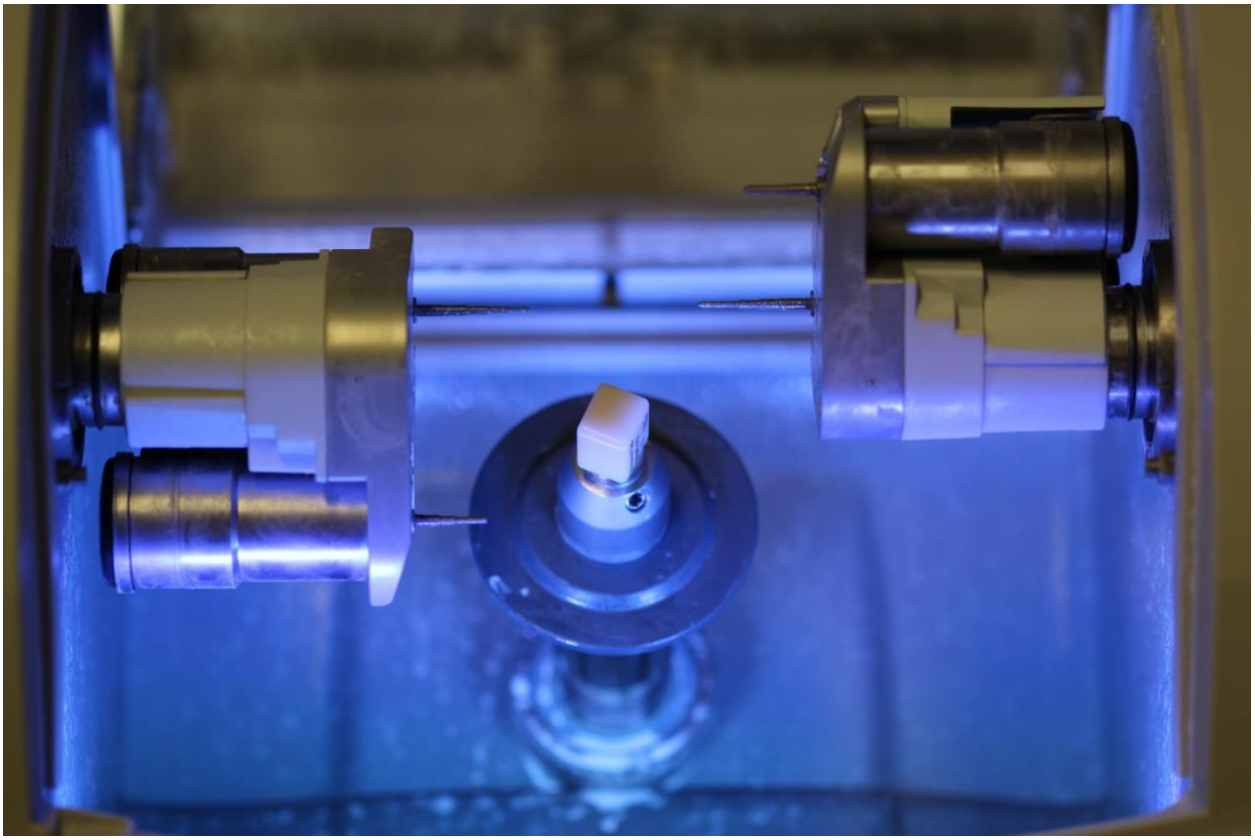


Figure 4. Milling Parameters for CEREC AC OMNICAM.

Figure 5. Milling Parameters for CEREC AC BLUECAM.

Figure 6. Dentoform/ Ivorine Teeth – Dentoform Columbia – M-PVR-1560 with full complement of teeth #1-32. Imaging confined only to left side.

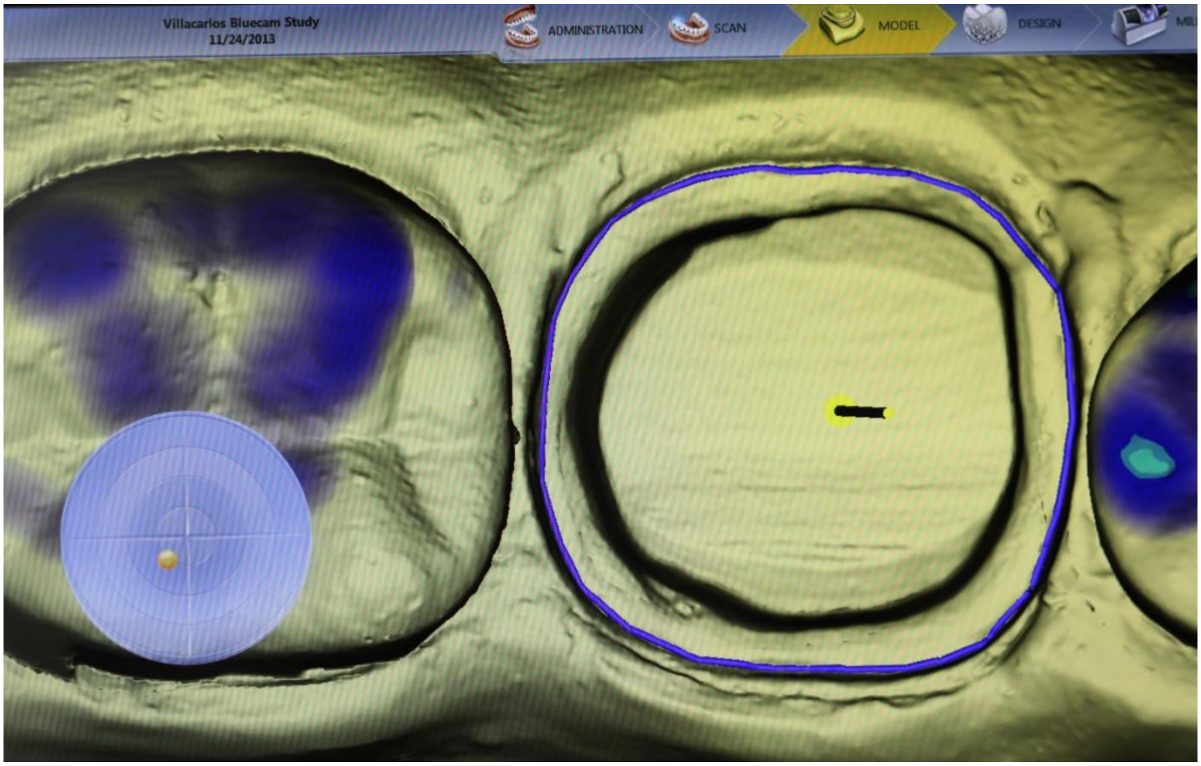
Figure 7. Ivorine Tooth #19 utilized in study for both BLUECAM and OMNICAM.

Figure 8. IPS Empress CAD blocks – Multi A2 shade/ C14 size block.

Figure 9. TiO2 Optispray utilized in Bluecam specimens on typodont.

Figure 10. CEREC 4 software by SIRONA used to image #19 - CEREC AC OMNICAM.

Figure 11. CEREC 4 software by SIRONA used to image #19 - CEREC AC BLUECAM inEOS.



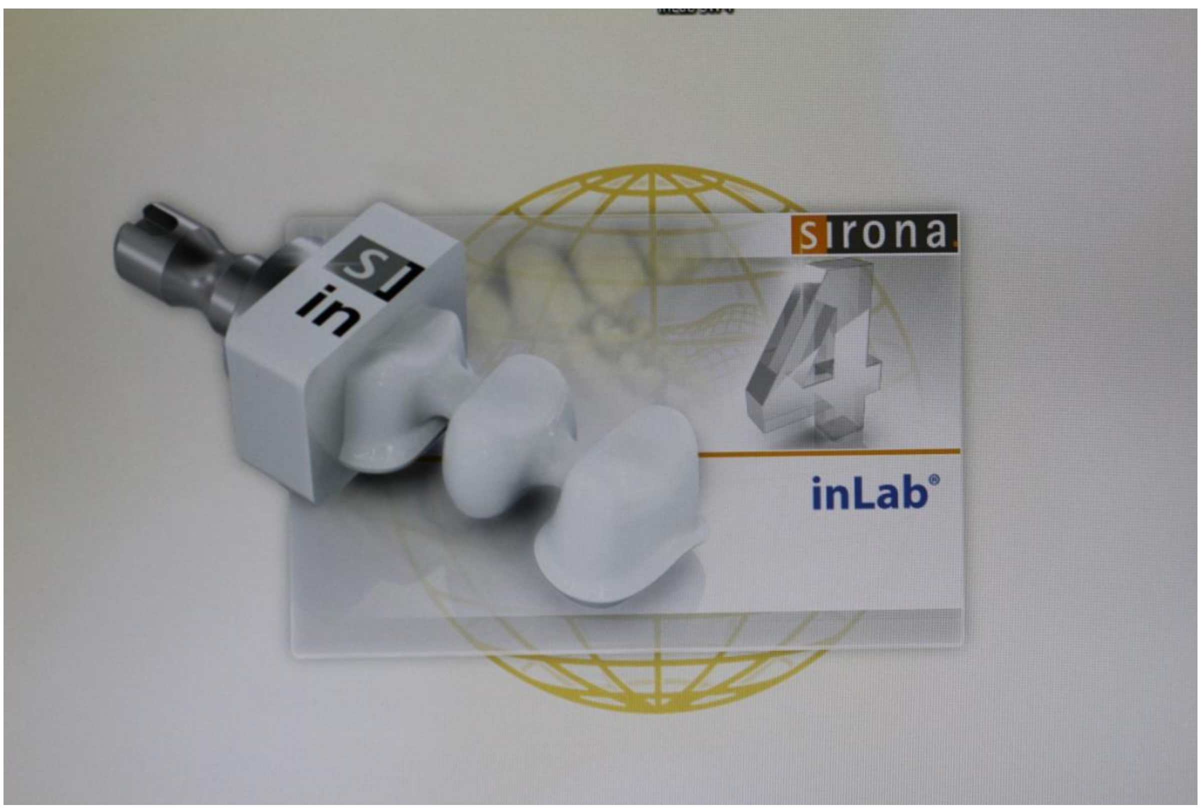


Figure 12. NEXUS 3 – RESIN CEMENT

Figure 13. SteREO Discovery. V20 Stereomicroscope – Carl Zeiss utilized for imaging of marginal gap on the BLUECAM and OMNICAM specimens.

Figure 14. Pilot study - Stereomicroscope image of magnification x80 prepared BLUECAM specimen #1 from mesial lingual line angle aspect of #19 at scale of 100um.

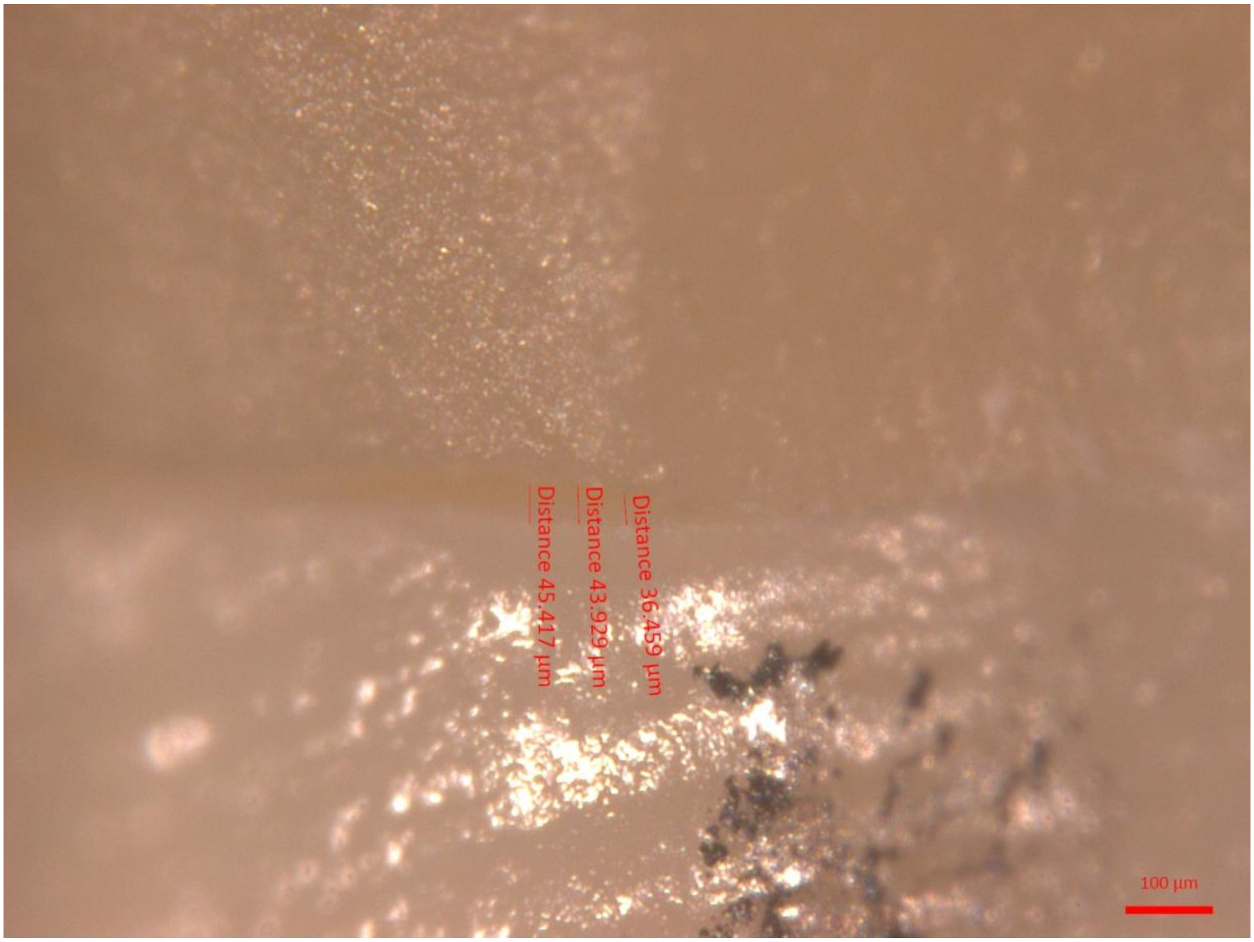


Figure 15. Stereomicroscope image at magnification of x80 of OMNICAM specimen #1 from mesial aspect of #19.

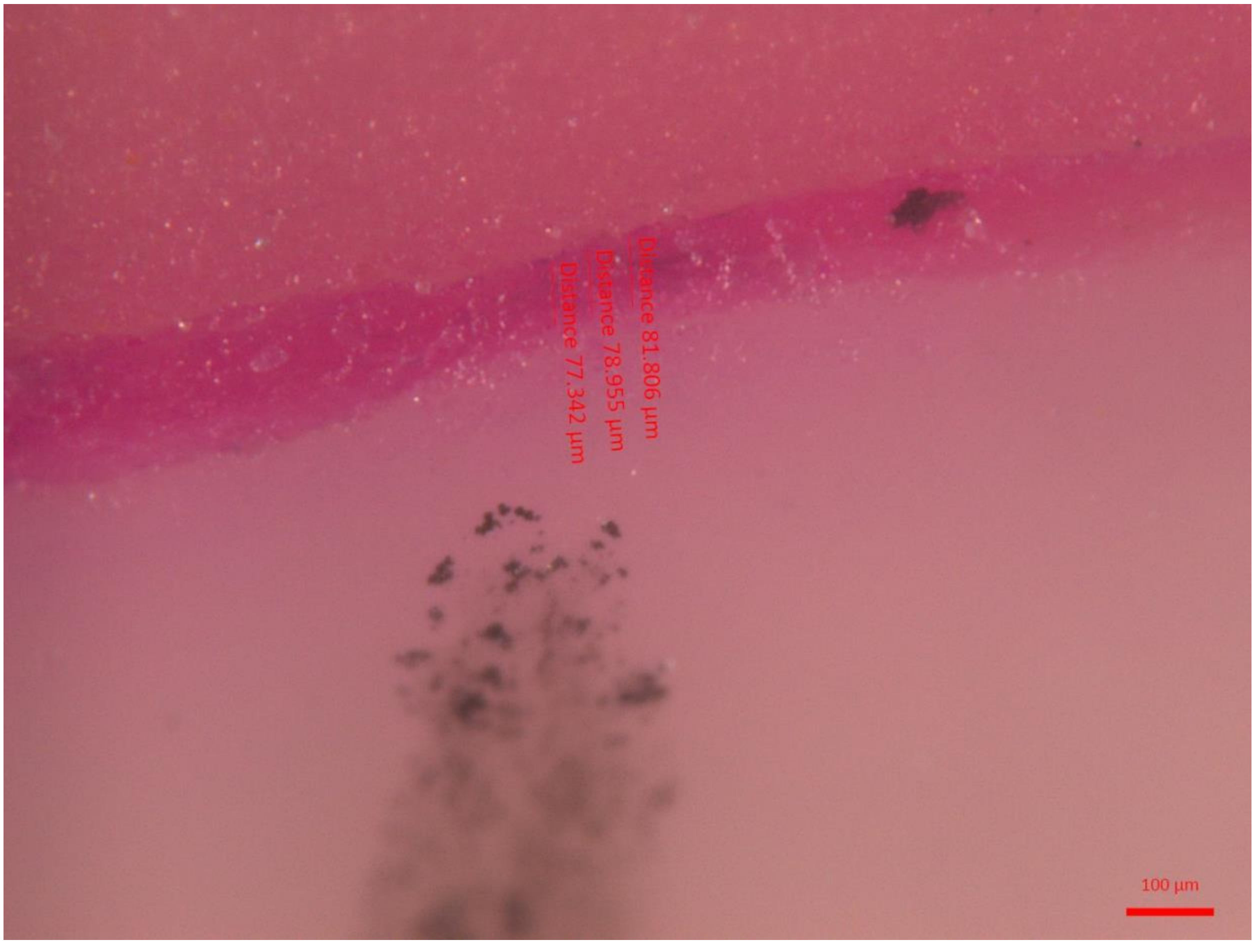
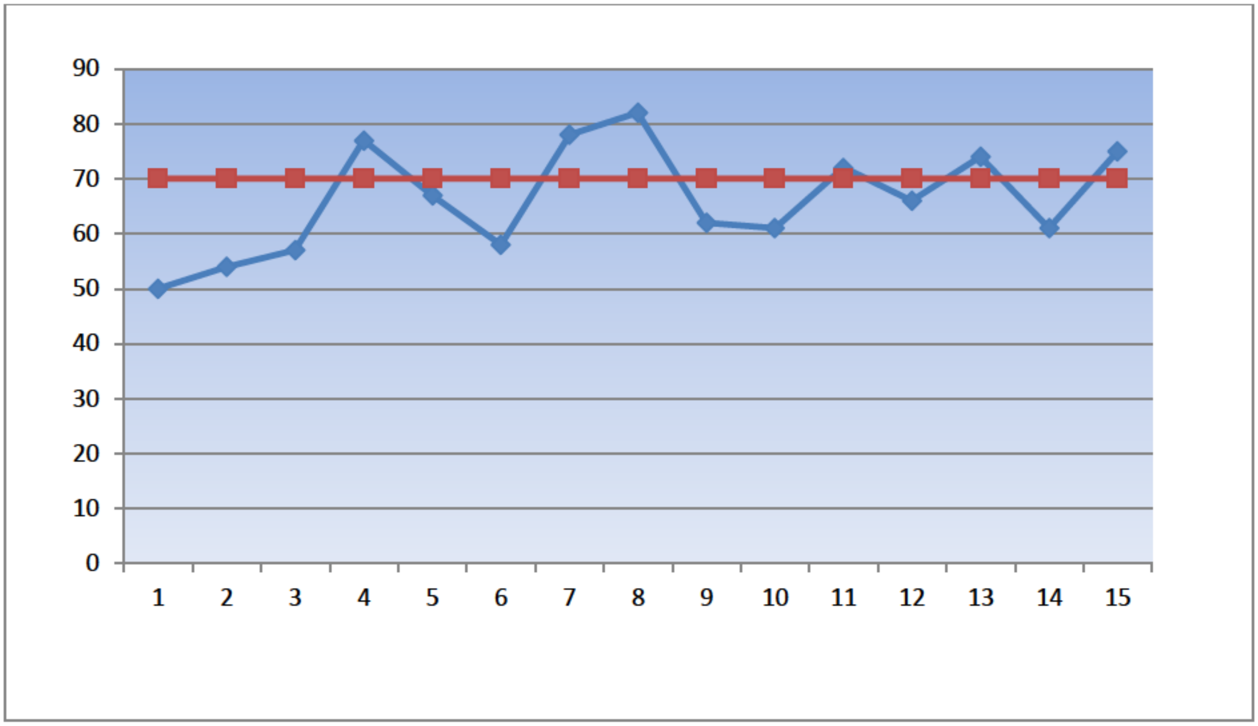
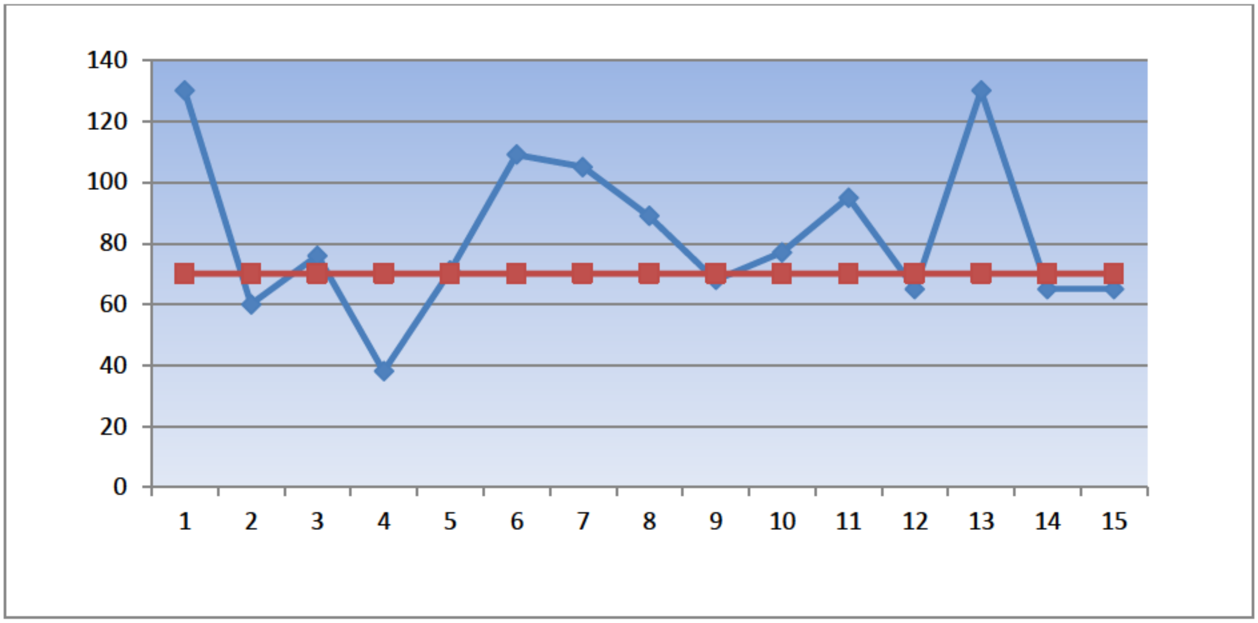


Figure 16. Graph showing averages among specimens for BLUECAM #1-15 vs. average marginal gap distances (0-90microns) for all locations denoted on Table 3.



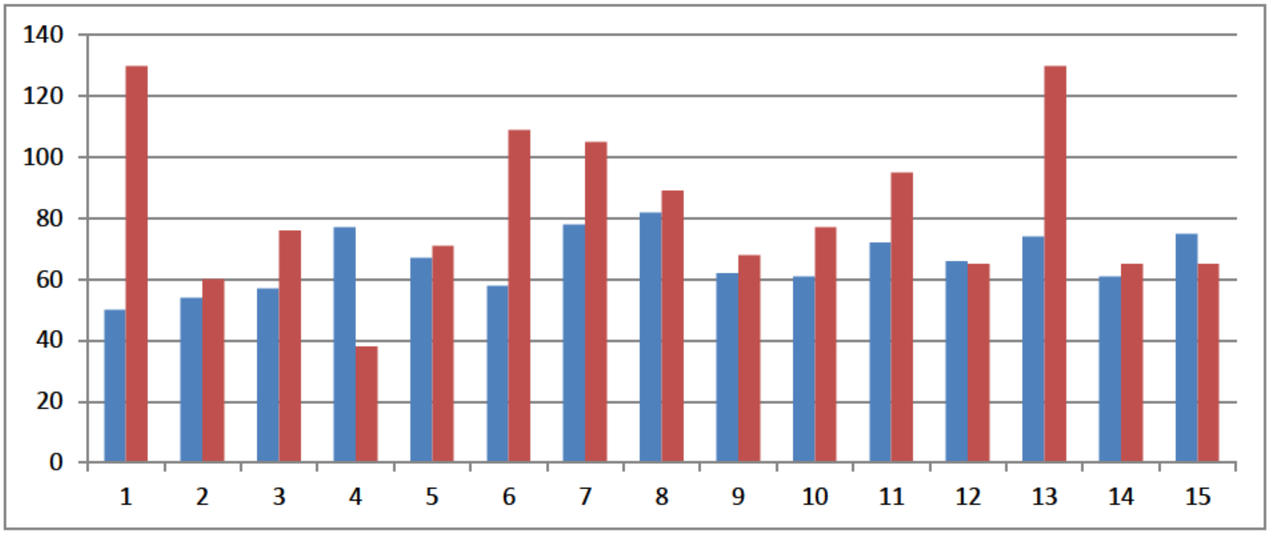
AVG =	**67**
STDEV=	**9.684056608**
Variance =	**68**

Figure 17. Graph showing averages among specimens for OMNICAM #1-15 vs. average marginal gap distances (0-90microns) for all locations denoted on Table 4.

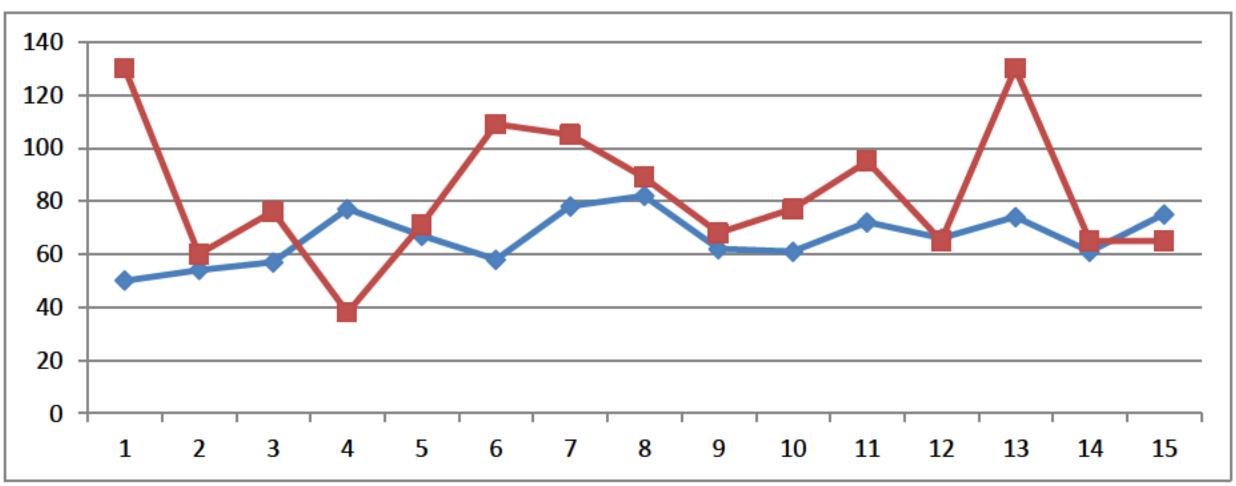


AVG=	**82**
STDEV =	**26.37332707**
Variance =	**695**

Figure 18. Graphs showing overlay of OMNICAM (red)#1-15 & BLUECAM (blue) #1-15 vs. average marginal gaps on specimens.



BLUECAM	Statistics
AVG =	67
STDEV=	9.684056608
Variance =	68
OMNICAM	**Statistics**
AVG=	82
STDEV =	26.37332707
Variance =	695
t-test = 0.026	$p<0.05$



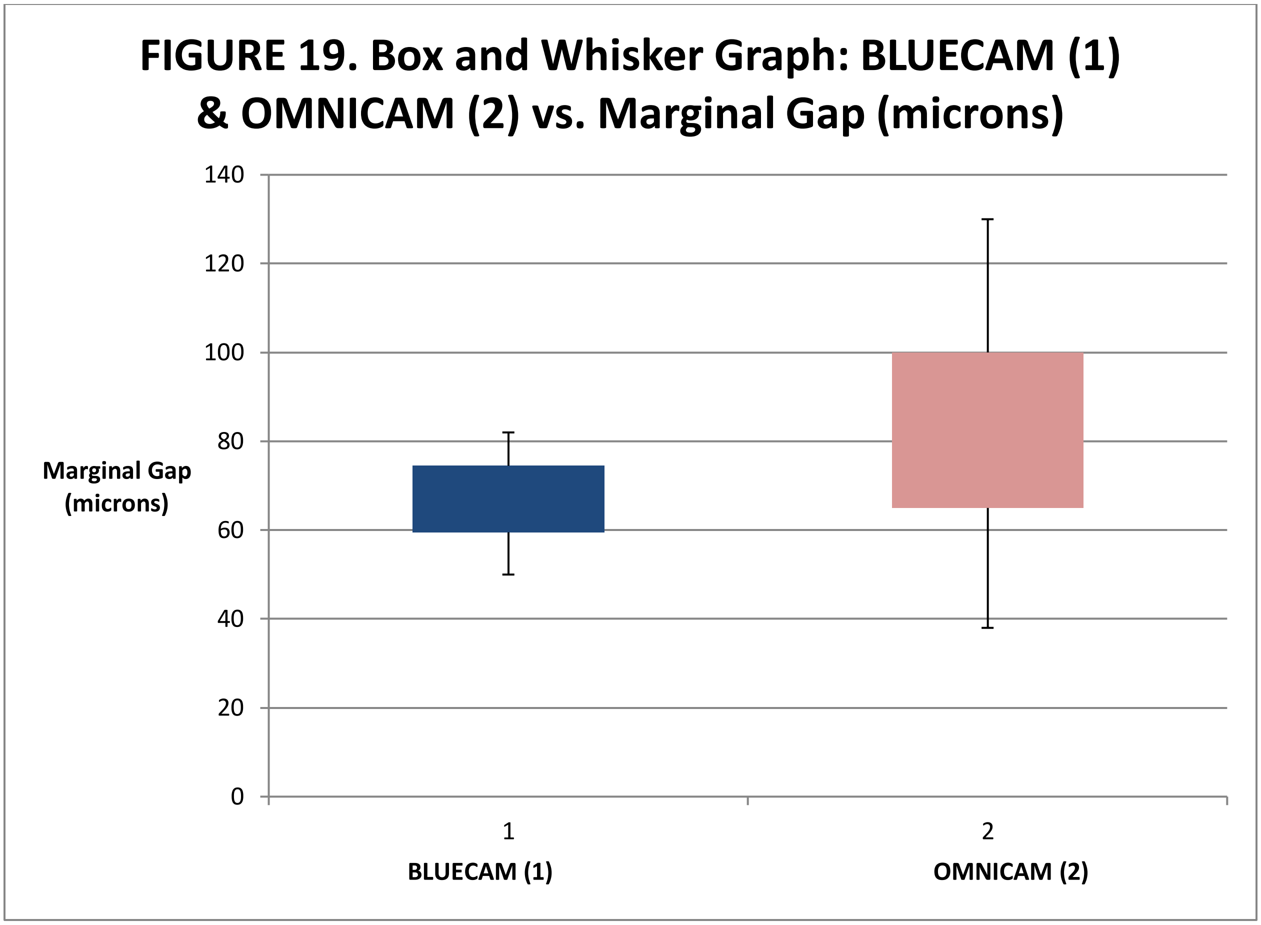


FIGURE 19. Box and Whisker Graph: BLUECAM (1) & OMNICAM (2) vs. Marginal Gap (microns)
140
120
100
80
60
40
20
0
Marginal Gap (microns)
1
2
BLUECAM (1)
OMNICAM (2)

Table 1: Comparison of traditional work flow with digital work flow.

Comparison of traditional work flow with digital work flow.		
WORK-FLOW STEP	**TRADITIONAL WORK FLOW**	**DIGITAL WORK FLOW**
Taking Impressions	10 minutes per arch	Two minutes per arch (Figure 1)
Filling Out Laboratory Prescription	Handwritten	Digital prescription entered on screen (Figure 2)
Submitting Case to Laboratory	Courier, one to three days	Electronic portal, 10 seconds
Designing and Fabricating a Full-Contour Restoration or Framework, if Required*	Must wait for model work, additional day	Completed from digital model
Fabricating Model*	Die stone, sectioning, with potential for error	Stereolithography models built overnight during framework creation
Finishing Restoration	Work flow varies according to the selected materials (for example, monolithic or polylithic materials)	Work flow varies according to the selected materials (for example, monolithic or polylithic materials)

* This step is not necessary for computer-aided design/computer-aided manufacturing production of monolithic restorations.

Table 2. Single calculation: Sample size estimation for comparative analysis of two groups.

Single Calculation: Sample Size Estimation	
Probability of Type I Error (alpha)	0.05
Power (1-beta)	0.80
The difference between the 2 groups to be detected	40
The expected within group standard devivation (SD)	37
Sample Size required (per group)	15

Table 3. CEREC AC BLUECAM specimens #1-4, marginal gap at random locations for mesial (M), mesial buccal line angle (MBLA), mid-buccal (mB), distal buccal line angle (DBLA), distal (D), distal lingual line angle (DLLA), mid-lingual (mL), and distal lingual line angle (DLLA).

OMNICAM specimen #	Location	distance (microns)	distance (microns)	distance (microns)
1	M	81.806	78.955	77.342
1	MBLA	200.144	177.771	193.12
1	mB	210.686	215.058	216.491
1	DBLA	198.371	190.75	190.774
1	D	242.794	248.393	233.159
1	DLLA	203.222	212.598	216.914
1	mL	124.148	130.194	139.483
1	MLLA	30.278	25.914	21.248
2	M	84.832	80.365	84.832
2	MBLA	22.759	27.292	19.681
2	mB	34.951	37.968	53.18
2	DBLA	34.852	39.361	33.34
2	D	116.658	104.634	98.414
2	DLLA	46.955	44.007	43.929
2	mL	74.181	72.667	69.639
2	MLLA	83.388	72.682	60.631
3	M	49.981	49.981	57.528
3	MBLA	89.371	103.222	94.056
3	mB	51.472	48.444	71.169
3	DBLA	31.792	30.617	29.12
3	D	102.342	87.361	101.555
3	DLLA	117.977	126.389	133.772
3	mL	112.528	81.385	70.049
3	MLLA	59.351	63.871	67.449
4	M	45.517	48.444	60.574
4	MBLA	53.073	43.903	45.417
4	mB	45.643	47.802	67.703
4	DBLA	38.119	50.324	62.088
4	D	19.739	21.248	15.139
4	DLLA	33.34	31.828	30.429
4	mL	33.34	30.429	43.929
4	MLLA	15.139	19.739	13.709

Table 3 (continued). CEREC AC BLUECAM specimens #5-8, marginal gap at random locations for mesial (M), mesial buccal line angle (MBLA), mid-buccal (mB), distal buccal line angle (DBLA), distal (D), distal lingual line angle (DLLA), mid-lingual (mL), and distal lingual line angle (DLLA).

OMNICAM specimen #	Location	distance (microns)	distance (microns)	distance (microns)
5	M	40.154	46.123	47.178
5	MBLA	46.955	45.517	47.028
5	mB	107.657	121.347	132.021
5	DBLA	72.808	86.94	144.106
5	D	166.968	158.033	155.017
5	DLLA	22.759	26.134	25.914
5	mL	27.292	26.134	27.418
5	MLLA	33.614	41.321	72.176
6	M	74.196	84.778	92.36
6	MBLA	22.909	15.214	13.625
6	mB	113.632	124.884	130.23
6	DBLA	196.858	193.784	190.966
6	D	243.741	240.713	237.7
6	DLLA	28.804	36.333	30.278
6	mL	44.007	48.468	57.707
6	MLLA	127.176	128.681	151.419
7	M	71.153	77.223	78.722
7	MBLA	167.358	160.172	147.097
7	mB	30.617	28.923	31.792
7	DBLA	174.104	187.777	186.214
7	D	87.923	72.73	65.168
7	DLLA	118.083	112.028	123.149
7	mL	147.128	134.736	163.612
7	MLLA	56.014	49.958	51.472
8	M	90.833	90.846	87.858
8	MBLA	136.258	125.662	127.176
8	mB	81.75	80.293	87.858
8	DBLA	186.214	177.287	177.287
8	D	39.39	42.389	28.923
8	DLLA	24.222	18.167	27.292
8	mL	107.657	112.528	104.853
8	MLLA	59.486	65.954	72.745

Table 3 (continued). CEREC AC BLUECAM specimens #9-12, marginal gap at random locations for mesial (M), mesial buccal line angle (MBLA), mid-buccal (mB), distal buccal line angle (DBLA), distal (D), distal lingual line angle (DLLA), mid-lingual (mL), and distal lingual line angle (DLLA).

OMNICAM specimen #	Location	distance (microns)	distance (microns)	distance (microns)
9	M	151.396	140.792	148.361
9	MBLA	166.535	154.535	136.46
9	mB	39.477	40.875	40.875
9	DBLA	98.414	98.693	99.963
9	D	48.468	40.903	36.365
9	DLLA	34.819	31.828	25.736
9	mL	19.681	19.739	11.021
9	MLLA	15.139	24.269	25.736
10	M	133.222	127.203	125.662
10	MBLA	21.194	21.248	19.681
10	mB	43.929	53.18	57.528
10	DBLA	172.59	175.637	177.131
10	D	62.143	42.631	53.18
10	DLLA	27.292	18.23	19.739
10	mL	139.483	142.507	153.09
10	MLLA	27.25	25.781	24.269
11	M	45.417	59.042	66.628
11	MBLA	42.497	39.622	40.987
11	mB	54.689	65.168	66.68
11	DBLA	126.099	134.813	152.97
11	D	66.68	71.169	76.072
11	DLLA	169.373	154.164	152.302
11	mL	152.91	139.286	130.274
11	MLLA	92.36	95.387	99.928
12	M	51.561	68.142	75.755
12	MBLA	26.134	36.616	37.877
12	mB	19.739	21.194	16.721
12	DBLA	40.987	48.539	46.955
12	D	84.899	76.072	71.73
12	DLLA	28.764	24.222	24.411
12	mL	222.727	222.958	219.702
12	MLLA	27.25	31.792	42.873

Table 3 (continued). CEREC AC BLUECAM specimens #13-15 marginal gap at random locations for mesial (M), mesial buccal line angle (MBLA), mid-buccal (mB), distal buccal line angle (DBLA), distal (D), distal lingual line angle (DLLA), mid-lingual (mL), and distal lingual line angle (DLLA).

OMNICAM specimen #	Location	distance (microns)	distance (microns)	distance (microns)
13	M	281.783	274.014	266.793
13	MBLA	130.757	133.257	127.311
13	mB	75.71	72.73	78.78
13	DBLA	175.715	179.158	171.738
13	D	135.279	141.312	138.295
13	DLLA	112.069	90.884	84.791
13	mL	95.375	87.806	80.236
13	MLLA	72.73	60.631	65.168
14	M	107.529	95.387	92.397
14	MBLA	87.819	92.459	83.278
14	mB	13.957	19.681	13.625
14	DBLA	59.351	62.529	59.985
14	D	122.111	121.111	115.066
14	DLLA	19.681	25.781	24.222
14	mL	48.468	43.903	45.442
14	MLLA	65.168	66.628	76.237
15	M	77.268	75.71	78.722
15	MBLA	45.417	43.929	36.459
15	mB	15.139	16.653	19.739
15	DBLA	90.947	102.989	124.222
15	D	80.236	90.833	92.36
15	DLLA	78.78	74.242	72.667
15	mL	94.409	98.17	64.157
15	MLLA	30.278	45.417	33.306

Table 4. Raw data from CEREC AC OMNICAM specimens #1-4, marginal gap at random locations for mesial (M), mesial buccal line angle (MBLA), mid-buccal (mB), distal buccal line angle (DBLA), distal (D), distal lingual line angle (DLLA), mid-lingual (mL), and distal lingual line angle (DLLA).

BLUECAM specimen #	Location	distance (microns)	distance (microns)	distance (microns)
1	M	62.143	57.548	77.223
1	MBLA	83.278	80.25	78.737
1	mB	48.821	51.561	56.523
1	DBLA	133.231	122.625	133.3
1	D	116.047	113.471	112.253
1	DLLA	43.059	41.872	38.329
1	mL	66.766	63.601	69.655
1	MLLA	24.269	22.708	19.681
2	M	21.41	16.653	24.411
2	MBLA	133.955	134.668	125.935
2	mB	15.139	22.708	19.739
2	DBLA	27.418	36.459	30.278
2	D	59.525	47.32	46.043
2	DLLA	80.25	90.884	77.342
2	mL	65.027	65.027	69.474
2	MLLA	34.951	31.792	33.614
3	M	72.667	65.168	48.444
3	MBLA	42.497	39.477	33.443
3	mB	49.981	54.521	72.682
3	DBLA	124.471	113.632	112.191
3	D	83.388	83.758	80.592
3	DLLA	24.222	28.923	28.764
3	mL	45.442	45.417	40.903
3	MLLA	30.278	34.852	34.819
4	M	104.557	96.995	107.657
4	MBLA	29.12	33.306	30.278
4	mB	24.411	33.306	37.847
4	DBLA	21.248	25.914	31.792
4	D	148.431	124.471	134.813
4	DLLA	118.326	118.171	124.176
4	mL	86.292	89.371	81.971
4	MLLA	87.61	85.223	96.224

Table 4 (continued). Raw data from CEREC AC OMNICAM specimens #5-8, marginal gap at random locations for mesial (M), mesial buccal line angle (MBLA), mid-buccal (mB), distal buccal line angle (DBLA), distal (D), distal lingual line angle (DLLA), mid-lingual (mL), and distal lingual line angle (DLLA).

BLUECAM specimen #	Location	distance (microns)	distance (microns)	distance (microns)
5	M	104.995	98.693	100.1
5	MBLA	64.46	76.657	72.176
5	mB	56.987	52.661	45.543
5	DBLA	15.439	18.417	17.261
5	D	91.148	88.131	84.899
5	DLLA	44.137	54.521	46.955
5	mL	59.061	62.088	66.886
5	MLLA	71.73	64.032	66.886
6	M	100.989	105.027	100.249
6	MBLA	80.236	78.722	81.764
6	mB	62.364	48.657	41.321
6	DBLA	29.12	33.34	40.903
6	D	77.208	101.431	87.858
6	DLLA	27.25	28.923	16.653
6	mL	28.804	33.306	42.416
6	MLLA	57.308	45.164	47.004
7	M	63.745	54.5	65.168
7	MBLA	65.728	79.936	97.09
7	mB	21.194	34.819	25.736
7	DBLA	42.497	30.316	33.34
7	D	176.321	166.562	157.801
7	DLLA	38.922	55.106	59.486
7	mL	114.986	120.751	109.859
7	MLLA	93.837	89.665	87.032
8	M	117.363	117.753	107.253
8	MBLA	77.608	58.906	45.011
8	mB	109.053	102.811	105.43
8	DBLA	66.68	62.088	53.008
8	D	136.258	130.274	127.311
8	DLLA	40.987	40.875	37.847
8	mL	69.705	63.601	69.655
8	MLLA	77.445	77.579	75.936

Table 4 (continued). Raw data from CEREC AC OMNICAM specimens #9-12, marginal gap at random locations for mesial (M), mesial buccal line angle (MBLA), mid-buccal (mB), distal buccal line angle (DBLA), distal (D), distal lingual line angle (DLLA), mid-lingual (mL), and distal lingual line angle (DLLA).

BLUECAM specimen #	Location	distance (microns)	distance (microns)	distance (microns)
9	M	77.579	86.768	88.274
9	MBLA	50.05	31.792	37.968
9	mB	37.847	50.05	54.689
9	DBLA	44.137	41.127	34.951
9	D	130.625	126.099	142.595
9	DLLA	24.222	25.914	28.764
9	mL	43.929	50.164	58.024
9	MLLA	80.592	75.163	81.525
10	M	84.832	81.876	86.345
10	MBLA	40.903	48.468	48.657
10	mB	57.308	46.043	52.026
10	DBLA	35.633	43.693	41.182
10	D	57.548	65.115	60.556
10	DLLA	63.655	65.536	76.237
10	mL	54.166	80.293	92.459
10	MLLA	62.088	72.73	62.143
11	M	73.435	81.385	79.648
11	MBLA	52.552	56.096	51.494
11	mB	72.808	66.766	62.364
11	DBLA	68.142	65.115	57.548
11	D	104.502	104.502	110.773
11	DLLA	80.365	71.298	72.919
11	mL	65.097	65.097	68.125
11	MLLA	64.229	70.684	70.441
12	M	54.521	72.667	74.242
12	MBLA	90.959	82.364	90.022
12	mB	61.755	65.115	63.547
12	DBLA	28.923	39.622	39.477
12	D	34.819	50.05	43.903
12	DLLA	121.734	106.845	129.036
12	mL	68.728	56.523	55.023
12	MLLA	71.298	56.096	34.819

Table 4 (continued). Raw data from CEREC AC OMNICAM specimens #13-15 marginal gap at random locations for mesial (M), mesial buccal line angle (MBLA), mid-buccal (mB), distal buccal line angle (DBLA), distal (D), distal lingual line angle (DLLA), mid-lingual (mL), and distal lingual line angle (DLLA).

BLUECAM specimen #	Location	distance (microns)	distance (microns)	distance (microns)
13	M	46.955	51.494	51.494
13	MBLA	49.289	47.15	54.035
13	mB	77.223	84.791	90.884
13	DBLA	56.014	46.931	57.548
13	D	86.504	83.484	89.435
13	DLLA	115.414	112.395	109.378
13	mL	36.459	36.365	25.736
13	MLLA	125.662	122.634	131.717
14	M	74.242	63.601	62.088
14	MBLA	87.361	85.115	83.936
14	mB	29.12	21.41	26.439
14	DBLA	60.726	57.707	56.523
14	D	101.532	95.962	85.438
14	DLLA	51.561	52.986	53.008
14	mL	78.737	90.947	73.06
14	MLLA	19.739	28.804	28.764
15	M	97.184	105.158	100.841
15	MBLA	42.631	40.987	61.027
15	mB	54.584	51.672	47.15
15	DBLA	143.66	137.172	145.373
15	D	88.274	90.137	91.148
15	DLLA	56.014	53.008	51.494
15	mL	57.607	57.846	56.198
15	MLLA	62.364	64.032	63.547

Table 5. BLUECAM marginal gap averages from all locations denoted from Table 3 for all specimens #1-15 compared to the CEREC XL parameter (70microns).

BLUECAM Specimen #	Sample Average (microns)	Standard Deviation	XL Parameter
1	50	3	70
2	54	2	70
3	57	2	70
4	77	1	70
5	67	1	70
6	58	2	70
7	78	1	70
8	82	2	70
9	62	1	70
10	61	1	70
11	72	1	70
12	66	1	70
13	74	1	70
14	61	1	70
15	75	1	70

AVG =	67
STDEV=	9.684056608
Variance =	68

Table 6. OMNICAM marginal gap averages from all locations denoted from Table 4 for all specimens #1-15 compared to the CEREC XL parameter (70microns).

Omnicam Specimen #	Sample Average (microns)	Standard Deviation	XL Parameter
1	**130**	3	70
2	**60**	1	70
3	**76**	1	70
4	**38**	2	70
5	**71**	1	70
6	**109**	2	70
7	**105**	2	70
8	**89**	1	70
9	**68**	1	70
10	**77**	1	70
11	**95**	1	70
12	**65**	1	70
13	**130**	3	70
14	**65**	1	70
15	**65**	1	70

AVG=	**82**
STDEV =	**26.37332707**
Variance =	**695**

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