



Technical Analysis of Clinical Digital Photographs

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ABSTRACT Clinical digital photography adds an efficient, new dimension to the information provided to the dental technician. Through the use of digital photography, the clinician can create a series of images that communicate key prosthetic facial and dental landmarks for the dental technician to use in analyzing and creating the final prosthesis for the patient.

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For the past 100 years, one of the key objectives has been to recreate a virtual patient model through the use of articulated dental plaster models. In the 1920s, McCollum and Charles Stuart pioneered the use of dental articulators as a method to transfer anatomic determinants in order to create a modeling device for articulating the human bite, thus improving the prosthetic results created by laboratories.¹ The use of articulators today provide needed anatomic information but falls short on key areas related to facial soft tissue, symmetry, and key skeletal relations of the jaw to other facial landmarks.

Clinical film photography have been known to provide useful information not captured by an articulator, but are necessary to create a more comprehensive virtual model of the patient. The

inefficiency of film development and duplication, along with its expense, has been a barrier to making photography a standard of the laboratory information gathered by the dentist.

Digital photography has removed that barrier. Now, capturing images and their duplication is much more efficient and easy to assemble for transfer to the laboratory technician, adding useful information that can be referenced for patient modeling perspectives.

Having a more comprehensive visual representation of a patient is a desirable objective because it facilitates the creation of prosthetic work that more concisely blends with the biology and esthetics of the living patient, as opposed to only information obtained from stone models and lab prescription. In conversing with dentists or specialists, the Achilles heel of their practice is the dental laboratory's

inability to consistently and accurately create a prosthesis or restoration that meets the patient's expectations. The information provided through photography can help the technician and dentist reach their mutual objectives more consistently by providing a common visual data, which aids the technician in visualizing how the stone model's anatomical and dentition landmarks correlate to the patient's facial anatomy during prosthetic fabrication.

Photography adds many of the skeletal and facial landmarks as they relate to the dentition's shape, shade, texture, and position, and has, up until now, been communicated with a facebow transfer, impressions, models, drawings, and written lab slips. Information regarding soft tissue and skeletal asymmetries, fullness of lips, along with the general landscape appearance of teeth was left to the lab technician's interpretation of the lab slip, which depends on his or her mental perception.

This article will utilize a series of 17 images that can easily be captured preceding patient treatment by utilizing a clinical digital camera, and will demonstrate the information that can be interpreted from these clinical photos. The dentist and lab team should identify the needed photographic information and the most beneficial series of images routinely needed by the laboratory. Another factor that should be anticipated is whether a lab will be viewing the images on a computer monitor or print medium as this will influence the reliability of factors such as color and the general appearance of the images. The topic of color calibration will not be covered in this article.

The author will demonstrate that having clinical photos of a patient will communicate a more complete virtual patient model, showing key prosthetic facial and dental landmarks for the dental

technician to analyze in creating a beautiful smile, improving biologic compatibility, and enhancing functional results.

A situation that might be analogous to using an articulator alone for the construction of prosthetic dental restorations will first be examined. There are three analogous parties: the homeowner (patient), the architect (dentist), and the builder (laboratory). Now, imagine trying to build a house remotely for an

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empty lot with only written information about the location landscape, slope, neighborhood, or style of house.

The builder followed exactly what was on the architect's plans. The house is delivered to the property on time, as promised, only to find it was a great disappointment. The floors were not level, the framework was not quite right, and the style was not in harmony with adjacent properties. Now, the builder is responsible for redesigning the house to perfection. Had the architect conveyed what he wanted using digital photographs showing ground and aerial views of the neighborhood, adjacent properties, lot size, elevations, and street views, the final outcome would have been much different.

Again, as it is illustrated, having a more comprehensive perspective and a more accurate visual model of the construction site will usually result in more consistent quality results.

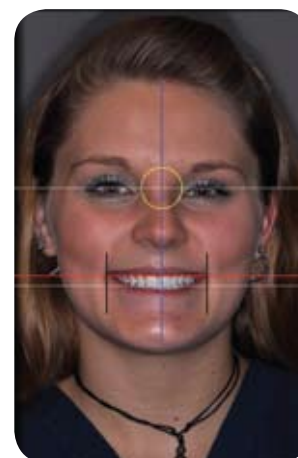


FIGURE 1. Average smile line is equivalent to the labial movement revealing 75 percent to 100 percent of the anterior teeth, as well as the interproximal gingival papilla. If the patient exposes the gingival margins during smiling, disappearing margins or metal margins on the buccal of the restoration might be disagreeable to the patient.

This sequence of 17 digital photographs reflects how sophisticated dentistry has become. By utilizing digital photography, the dental professional and the dental laboratory can bring the pieces of the esthetic patient puzzle together to create an exceptional prosthetic outcome.

Technical Analysis

This patient was selected because of her full complement of teeth and the symmetry of her face. Although a somewhat ideal subject is illustrated in these images, one can apply this analytical approach of facial geometry to less ideal arch forms and any combination of missing or restored teeth. The review of useful clinical photographic information utilized by laboratories covers multiple areas of interest such as shade, tooth morphology, facial symmetry, bite relations, aging of teeth, and attrition.

For brevity and focus, this article will limit itself to the discussion of facial and dental analysis that a dental technician can find useful for evaluation during the fabrication of prosthetic restorations. Shade evaluation will not be addressed.

Smile Line

The first step in the evaluation of this photo group is to evaluate the exposure of the anteriors during smiling as shown in **FIGURE 1**. One can evaluate the patient

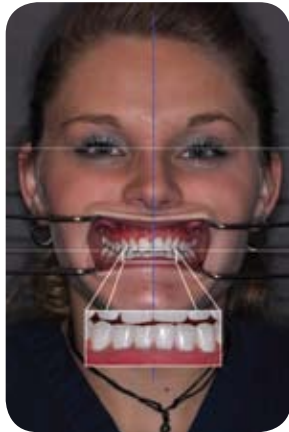


FIGURE 2. Clinical photography offers a wide array of views when cropping and expanding tools are used on the photo. The lower anteriors are viewed at close-up detail to examine line angles, texture, translucency, shape, and wear.



FIGURE 3. The buccal corridor refers to the dark or negative space visible during smile formation between the corners of the mouth and the buccal surfaces of the upper teeth (commissure). A prosthetic evaluation of the buccal corridor can play a role in the determination of including the first or second premolars in the treatment plan.

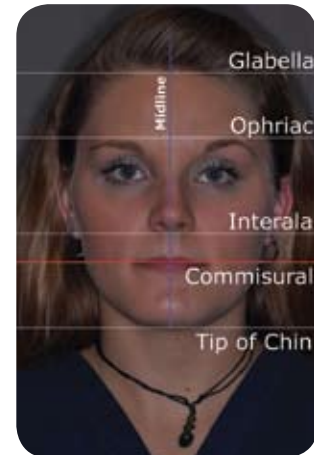


FIGURE 4. Measuring the face into three sections allows the technician to gain a general idea of facial horizontal harmony.

has an average smile line. Average smile line is equivalent to the labial movement revealing 75 percent to 100 percent of the anterior teeth, as well as the interproximal gingival papilla² (FIGURES 1, 10, AND 11).

The prosthetic observations determined from this patient information would allow the technician to understand the importance of establishing a correct gingival display and emergence profile as it relates to the patient's smile line. It must also be taken into consideration that it needs to be ideal, displayed or not. The material choice would also be a determining factor with a medium to high smile line, as well as margin prep design in order to hide metal show-through. For instance, if the patient has high smile line, consideration for the margin design could be a chamfer or shoulder margin, with material choice of 360-degree porcelain margin.

Smile Width

The smile width in FIGURE 1 reveals the number of teeth exposed from anterior to posterior. In this patient, eight to 10 teeth are visible. Analysis of the smile width is a determining factor in the correct planning of both buccal preparation and the material choice for the restoration. If the patient exposes the gingival margins during smiling, disappearing margins or metal margins on the buccal of the restoration might be disagreeable to the patient.

Midline

The midline in FIGURE 1 is drawn on the photograph from the center of the forehead through the tip of the nose and chin. When obvious asymmetries are present, it may be best to use the more reliable cupid bow (filtrum) as a midline landmark. The interpapillary line is drawn through the center of the pupils and the intersection of where the two lines form a cross. The more centered and perpendicular the two lines, the more harmonious the facial geometry.

Incisal Horizontal Plane

In examining the IHP symmetry in FIGURE 1, the incisal plane (whether normal, flat, or reverse) can be observed in this view. Additionally, a prosthetic determination or evaluation can be made as to the length, incisal curvature, and horizontal symmetry of the anteriors. The material choice can be evaluated relative to the amount of wear that is revealed regardless of the etiology of the wear. If the etiology of the wear on the occlusal table is determined to be correctable through TMJ analysis, then more options for material choice could be made available.

Occlusal Plane

The occlusal plane in FIGURE 2 is the horizontal evaluation of the maxillary occlusal surface as it relates to the ophriac or eyebrow line, the interpupillary line

and commissural line. The occlusal plane is normally parallel or 10 percent divergent to “camper’s plane.”³ To evaluate the occlusal plane geometric symmetry, the incisal edges of the central incisors, cuspids, and first molars are traced and evaluated for parallelism to the interpupillary line and commissural line.⁴ The prosthetic intervention is aimed at realigning the occlusal, horizontal, and interpupillary plane to re-establishing a more harmonious smile.^{5,6}

Commissural line (lips) is the horizontal line drawn from one corner of the mouth to the other. This line usually is parallel to the eyebrow line, (ophriac) IP line and the “O” plane.⁷⁻¹⁰

Buccal Corridor

The buccal corridor in FIGURE 3 refers to the dark or negative space visible during smile formation between the corners of the mouth and the buccal surfaces of the upper teeth (commissure). Two aspects of smile esthetics are the buccal corridor width (the difference between the visible maxillary posterior dentition width and the inner lip commissure width); and the smile arch (the curvature of the maxillary teeth in relation to the curvature of the lower lips or tooth/lip arc difference).¹¹ The ideal arch form is broad and conforms to a “U” shape.

A narrow arch form causes the anterior teeth to appear too dominant,

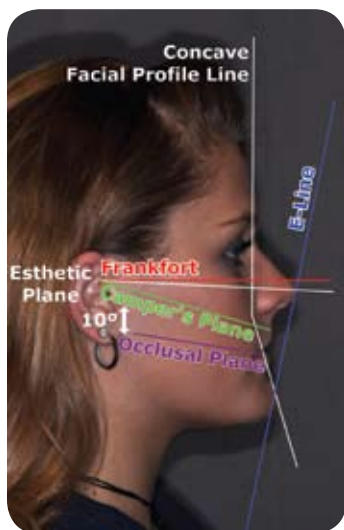


FIGURE 5. The facial profile line is evaluated by drawing a vertical line through the glabella, subnasal, and tip of the chin. This angle, when formed, designates either a convex, concave, or straight, normal facial profile. A normal facial profile is roughly 170 degrees. The Frankfort plane represents, by definition, the horizontal plane, even if during clinical observation it is, in fact, parallel with the horizon only when the patient bends the head slightly forward.

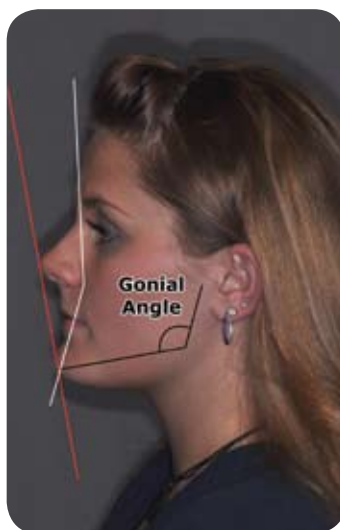


FIGURE 6A. This photo offers insight as to the skeletal classification of occlusion when restoring large edentulous areas as well as understanding wear patterns on the remaining teeth, thus resulting in tooth position for strength and restorative material choice.

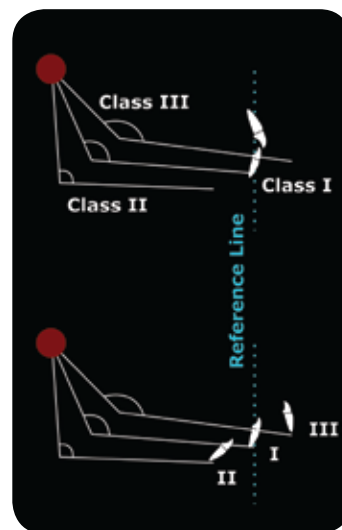


FIGURE 6B. In the Figure 6 profile photo, one can observe the patient has a larger gonial angle and the tendency will become more class III.

creating a negative space in the posterior. A prosthetic evaluation of the buccal corridor can play a role in the determination of including the first or second premolars in the treatment plan. Orthodontic treatment may be indicated if the buccal corridor is too narrow. In **FIGURE 3**, the lower lip smile line is evaluated to help establish the incisal smile line of the upper anterior teeth (**FIGURES 3 AND 4**).

Measuring the face into three sections allows the technician to gain a general idea of facial horizontal harmony. With the aforementioned facial landmarks, the face is divided into three vertical sections and measured for equality between sections from the hairline to the eyebrow to the interala to the chin, allowing evaluation of vertical and horizontal symmetry. If the horizontal lines are out of parallel with each other, the clinician might discuss with the patient the desired horizontal plane on which to build the occlusal plane.¹² Additionally, the use

of a facebow will capture the current occlusal plane and will be validated by the digital photographs. The technician then has a visualization of the disharmony or relative harmony of the facial geometry versus the true occlusal plane.

Facial proportions in **FIGURE 4** are observed by dividing the face into three equal parts. If the lower one-third proportion is not equal to the middle third, the vertical dimension might be decreased or increased according to desired facial symmetry. The vertical position would be validated by reversible esthetic means, such as composite mock-ups, or a diagnostic wax-up that could be made into shelled-out acrylic temporaries to test new vertical dimensions.

E-Line — Facial Profile Line — Frankfort Line — Esthetic Plane — Camper's Plane

The E-line, not to be confused with the esthetic plane, helps the technician evaluate lip support and the classification of anterior occlusions such as overjet. The E-line is determined by the line that

connects to the tip of the nose and to the tip of the chin. Normal upper lip profile to the E-line is about 4 mm posterior to the line, while the lower lip is about 2 mm posterior. According to Ricketts, the E-line measurement can be altered confidently by prosthetic treatment and care should be taken when restoring the anterior teeth.¹³ At this point, the dental technician can verify the overjet, lip support, and labial inclination from the evaluation of the profile photographs in **FIGURES 5 AND 6** to be consistent with the dentist's diagnosis and treatment plan.

In **FIGURES 5 AND 6**, the facial profile line is evaluated by drawing a vertical line through the glabella, subnasal, and tip of the chin. This angle, when formed, designates either a convex, concave, or straight, normal facial profile. A normal facial profile is roughly 170 degrees.¹⁴

The Frankfort plane represents, by definition, the horizontal plane, even if clinical observation reveals it is, in fact, parallel with the horizon only when the patient tilts the head slightly forward.¹⁵⁻¹⁷ Conversely, when the patient's head is held erect, with the eyes gazing toward the horizon, the Frankfort plane lifts upward at the front to form an angle of



FIGURE 7. The lateral curve of Wilson and the curve of occlusion.



FIGURE 8. The curve of Spee and maximum intercuspation (MIP).



FIGURE 9. The curve of Spee.



FIGURES 10 AND 11. Emergence profile refers to the angle in which the tooth emerges from the gums. The technician must mimic the silhouette of the natural emergence of the tooth. The proper emergence profile will avoid swelling and inflammation.



FIGURE 12. The axial inclination of the anterior teeth should be a mirror image of the contralateral teeth, however, slight deviations in the same teeth may occur if kept harmonious.

about 8 degrees (although the angle could have considerable variation) with the arbitrary horizontal plane that is commonly referred to as the esthetic plane.¹⁵⁻¹⁸

The esthetic plane helps the technician articulate the upper cast on a fully adjustable articulator in the correct superior vertical incline.

The camper's plane, a line drawn from the inferior border of the ala to the tragus, can simulate the upper occlusal plane with a difference of 10 degrees between the camper's plane and occlusal plane at the distal aspect of the lines.¹⁹ These prosthetic measurements relate to prosthetic considerations, whether a denture, partial or a full-mouth rehabilitation case, can be helpful in determining the articulation and occlusal plane angle, which in turn sets up the rest of the occlusal considerations such as curve of Spee and curve of Wilson.

Gonial Angle

In the **FIGURE 6A** profile photo, one can observe the patient has a significantly large gonial angle and the

tendency will become more class III.²⁰ This gives the technician insight to the skeletal classification of occlusion when restoring large edentulous areas as well as understanding wear patterns on the remaining teeth, thus resulting in tooth position for strength and restorative material choice²¹ (**FIGURE 6B**).

Curve of Wilson/Curve of Spee

In **FIGURES 7-9**, the views demonstrate the curve of Wilson, curve of Spee, maximum intercuspation, and curve of occlusion.

The lateral curve of Wilson of the occlusal table is formed by the lingual inclination of the posterior teeth because the lingual cusps are lower than the buccal cusps, they form a curve with their antimeres.²²

The curve of Spee, as described by Von Spee, starts at the tips of the mandibular cuspids and follows the buccal cusps of the natural premolars and molars, and continues to the anterior border of the ramus.

The curve of occlusion is the occlusal

surface that makes simultaneous contact with the major portion of the incisal and occlusal prominences of the existing teeth.

Maximum intercuspation, MIP, refers to the occlusal position of the teeth of both arches fully interposition themselves with the cusps of the opposing teeth. All of the observations made from **FIGURES 7-9** play an important role in orthodontic and prosthetic rehabilitation, and from a technical point of view are used to determine esthetics, tooth morphology, and function.

Emergence Profile

Emergence profile refers to the angle in which the tooth emerges from the gums. The technician must mimic the silhouette of the natural emergence of the tooth. The proper emergence profile will avoid swelling and inflammation. This is particularly important when restoring implant restorations as shown in **FIGURES 7-11**, relating to the mind's eye of a harmonious emergence profile.



FIGURE 13. According to these measurements, the central should be 60 percent wider than the lateral, and, in turn, the lateral should be 60 percent greater than the cuspid that is in frontal view.

Gingival Harmony/Axial Inclination/ Golden Proportions

The overall esthetic evaluation by the clinician and patient are determined by the harmonious covering of the neck of the teeth by the gingival tissue. Ideally, the gingival margins should be kept parallel to the horizontal reference point aforementioned in this article (the interpapillary and commissural line). They should be a scalloped design and drawn apically down into the zeniths of the prospective anterior teeth. The zenith point of a tooth is the tallest point spanning vertically.

The gingival margins of the maxillary central incisors and the canines should be symmetric and in a more apical position compared to those of the maxillary lateral incisors.²³

When considering the tissue sculpture and emergence profile in an implant case, the dental technician can trace the proper gingival outline on the digital photograph and prepare the soft tissue replica by the sculpturing of the sulcus on a stone model with a red stripe football diamond bur. Consequently, the gingival zenith will be in harmony with the contralateral side for optimum esthetic desires.

The Axial Inclination

The axial inclination of the anterior teeth, compared to the midline, should have a slight incisal mesioinclination and a slight apical distoinclination.^{24,25} The axial inclination of the anterior teeth should be a mirror image of the contralateral teeth, however slight deviations in the same teeth



FIGURES 14A AND 15A. Eccentric movements are validated by these types of digital photographs, technically to assure the pass through wear facets are present on the teeth.



FIGURES 14B AND 15B. Regardless of the etiology of the wear patterns, the technician will take great care to replicate what has occurred in the patient's mouth.



may occur if kept harmonious. Angles contribute strongly to the fabrication of the prosthetic crown as it relates to lines, angles, and gingival zenith (**FIGURE 12**).

The Golden Proportion

The Golden Proportion measurements are widely used to develop a pleasing restoration to the mind's eye. The Golden Proportion is used by artists, mathematicians, and architects; but it was not until 1973 that Lombardi introduced into dentistry the application of the Golden Proportion, which was further developed by Levin in 1978.^{26,27} The Golden Proportion states that the ratio between the width of the lateral incisor and the central incisor should be 1:1.618, while the optimal ratio between the width of the lateral incisor and the cuspid is 1:0.618 (**FIGURE 13**). According to these measurements, the central should be 60 percent wider than the lateral, and, in turn, the lateral should be 60 percent greater than the cuspid that is in frontal view.²⁸ Individual tooth length to width ratios such as a 75-80 percent length of the tooth to the width of the tooth ratio has been shown to create the most esthetically pleasing guide by which sizes of teeth can be extrapolated.

Eccentric Movements

Eccentric movements are validated by these types of digital photographs technically to assure the pass through wear facets are present on the teeth. Anterior guidance can be evaluated on the casts as the technician replicates the patient's muscular eccentric movements (**FIGURES 14A AND 15A**).

By observing the wear and eccentric movements, the technician could better understand the etiology of the oral environment. From MIP to eccentric movements, the technical analysis will help create the replication of nature, while revealing the pinnacle of dentistry, when man-made material disappears into nature, emulating both function and invisible beauty (**FIGURES 14B AND 15B**).

Occlusal Patterns

The occlusal patterns and ridge groove direction, as well as occlusal layering and staining are present in these photos. Arch form as aforementioned can also be evaluated on **FIGURES 16 AND 17**. Circular anatomy, incisal embrasures, and proximal contacts are easily distinguished from this digital photograph.



FIGURES 16 AND 17. The occlusal patterns and ridge groove direction, as well as occlusal layering and staining, are present in these photos.



FIGURE 18. The photograph communicates the patient's exact crown shade.



FIGURE 19. If done incorrectly, light will refract off the matching shade, thus, giving false shade information.

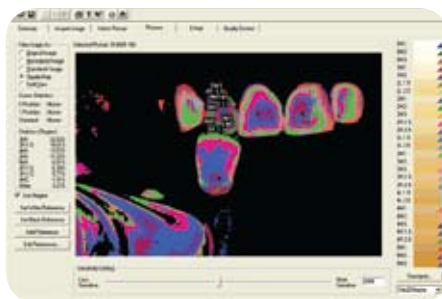


FIGURE 20. When the information is input into the computer, a patient-specific shade map will be created.



FIGURE 21. When crown shading is matched to perfection, the result will be perfect natural coloring that is difficult to set apart.

Without these visualizations, accurate fabrication could not be easily achieved.

Shading

With an absolute black and absolute white tab, 30-degree angled photos, and a matching shade tab, a dentist can easily communicate with the lab to have the patient's crown shaded perfectly (**FIGURE 18**). The matching shade tabs that closely represent the patient's shade should be photographed along with several 30-degree angled shots. These 30-degree shots must be angled to eliminate all light refractions in order to obtain the tooth's entire shade surface. If this is not done when inputting the shade information into the computer, there will be a void where the light was refracted, thus giving false shade or no shade at all (**FIGURE 19**).

The lab then inputs the information into the computer and prints out a unique shade map specific to only one patient (**FIGURE 20**). By using digital photographs for shading information, a common visual data could be used to verify the exact shade required for the final result, eliminating shading

errors, which in turn results in excellent patient satisfaction (**FIGURE 21**).

Conclusion

Digital photography adds an efficient, new dimension to laboratory information. Photography brings the mounting of laboratory cases closer to the visualization of the actual patient. When a series of analytical views are taken and placed in sequence, the clinician is providing a set of outstanding visuals that allows the technician or artisan to validate their articulated model mountings and comprehend landmarks that before were absent from the process of prosthetic fabrication.

With more information leading to greater precision, a technician can showcase his or her technical skills and become totally immersed in the patient's desired restorative outcome. Photography can turn plaster models into a human being that a lab technician can connect to as a case is being fabricated. As visual information becomes more robust with future breakthroughs in technology, the ability

to virtually simulate the living being will facilitate more functionally beautiful lifelike results. ■■■■

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