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PROPORTIONAL SMILE DESIGN USING THE RECURRING ESTHETIC DENTAL (RED) PROPORTION

Daniel H. Ward, DDS

Philosophers and mathematicians have long been fascinated by the relationship between mathematics and nature. The ancient Greek philosopher Pythagoras defined a *divine or golden proportion*, which "explains beauty in nature as it relates to the science of numbers."⁴ This proportion was used in ancient Greek architecture to design the Parthenon. Leonardo da Vinci used the golden proportion in his classic drawings of human anatomy. The practical correlations between proportions and beauty have carried forward to the present.

FACIAL PROPORTIONS

Plastic surgeons have long used the idea of proportions to define desirable facial relationships. The *rule of thirds* divides the face vertically into three approximately equal segments: the superior border of the face is the trichion (ideal hairline), the junction between the upper and middle thirds is the nasion, the junction of the middle and lower third is subnasale, and the inferior border is the menton.⁸ If the lower third of the face (subnasale to menton) subsequently is subdivided into thirds, the ideal position of the incisal plane is at the junction of the upper and middle thirds (Fig. 1).

DENTAL PROPORTIONS

It has been stated throughout denture literature that the height of the central incisor should be $\frac{1}{16}$ the height of the face from ideal hairline to the chin and

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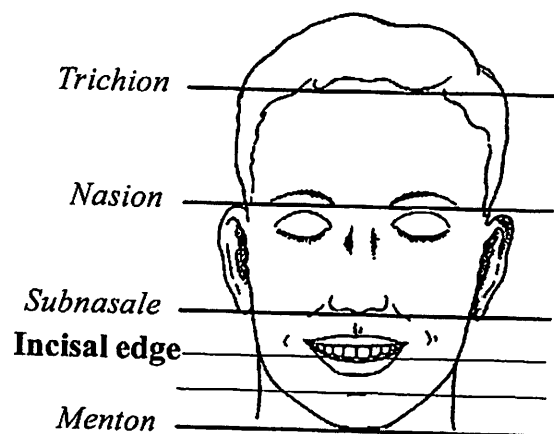


Figure 1. Rule of thirds.

that the width of the ideal central incisor should be $\frac{1}{16}$ the interzygomatic width.³ Another common rule of smile design is that the widths of the anterior six teeth as viewed from the frontal should be in golden proportion to the intercommissural width.⁶ The rule of thirds and the $\frac{1}{16}$ rule were combined in the Trubyte Tooth Indicator (Dentsply International, York, PA), which can be used as a guide in selecting denture teeth (Fig. 2).

GOLDEN PROPORTION

Levin⁵ used the golden proportion to relate the successive widths of the anterior teeth as viewed from the frontal. Levin⁵ stated that "the width of the central incisor should be in golden proportion to the width of the lateral incisor

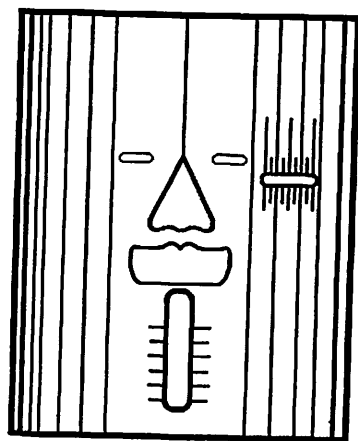


Figure 2. Trubyte Tooth Indicator (Dentsply International, York, PA).

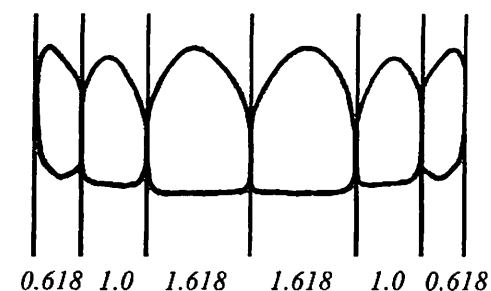


Figure 3. Anterior six teeth in golden proportion.

and that the width of the lateral incisor to the width of the canine should also be in golden proportion as should the width of the canine to the first premolar." The width of the central incisor should be multiplied by the value defined as the golden proportion, which is 0.618, or approximately 62%. The resultant width of the lateral incisor should be multiplied by 62% to give the width of the canine as viewed from the frontal. Figure 3 shows the outline of the anterior six teeth drawn to golden proportion. This concept of *as viewed from the frontal* is essential in applying the use of the golden proportion.

REPEATED RATIO

Lombardi⁶ described the use of a "continuous proportion or repeated ratio which has been established between the width of central and lateral incisor and is continued in the ratio of the placement of the remaining teeth and spaces." The proportion of the width of the central incisor and the lateral incisor should be consistent between the width of the lateral incisor and the canine and from the canine to the first premolar moving distally. The ratio between the width of the central incisor and the lateral incisor should be applied consistently to define the desired ratio between the lateral incisor and the canine.

RECURRING ESTHETIC DENTAL (RED) PROPORTION

The golden proportion as defined by Levin⁵ is limited to use of the 62% proportion. (The 62% proportion comes from the golden proportion of 0.618). The author believes that when the golden proportion is used, the lateral incisor appears too narrow, and the resulting canine is not prevalent enough. Preston⁹ reported that the golden proportion was found in the relationship between the maxillary central and lateral incisors in only 17% of the casts of patients he studied when viewed from the frontal. The concept of evaluating the frontal view is useful, however. The idea of a continuous proportion or repeated ratio as defined by Lombardi⁶ opens up the idea of using a continuous proportion not necessarily limited to the 62% proportion. This idea implies, however, that the ratio of the widths established between the central and lateral incisors then must be used as one moves distally. If the elements of both concepts are combined, one derives what the author has defined as the recurring esthetic dental (RED) proportion. The RED proportion states that the propor-

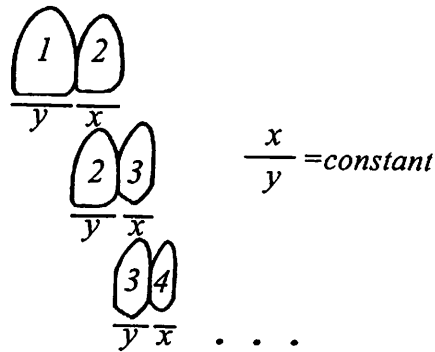
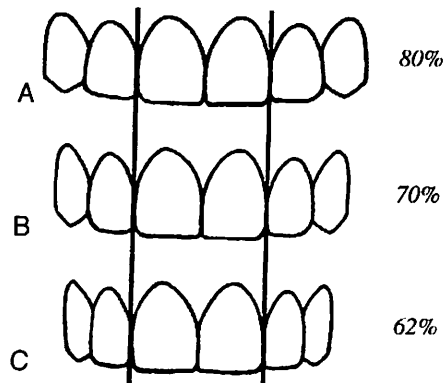


Figure 4. Graphic definition of RED proportion.

tion of the successive widths of the teeth as viewed from the frontal should remain constant as one moves distally (Fig. 4). Rather than being locked into using the 62% proportion, the dentist can use the proportion of his or her own choosing as long as the dentist is consistent while moving distally. Instead of having to accept the proportion already defined by the widths of the central and lateral incisors, the dentist can define his or her desired RED proportion.

The use of the RED proportion gives greater flexibility. In Figure 5, the central incisors are all the same width. Figure 5A has a lateral incisor that is 80% the width of the central incisor and a canine that is 80% the width of the lateral incisor. As can be seen, the canine is especially wide and gives the appearance of denture teeth laid out flatly side by side on carding wax. In Figure 5B, a 70% RED proportion is used. Several studies that evaluated the ratio of the widths of the maxillary lateral to the central incisor on sample patients reported mean proportions of 66% to 78%.^{2,9} In Figure 5C, the 62% RED proportion is used, which corresponds to the golden proportion. Although an approximate 70% RED proportion is preferred by the author, the RED proportion should be modified to fit the face, skeletal structure, and general body type of the patient. A person who is an ectomorph would be more likely to be able to use a smaller RED proportion, and an endomorph would use a larger RED proportion.



WIDTH-TO-HEIGHT RATIO

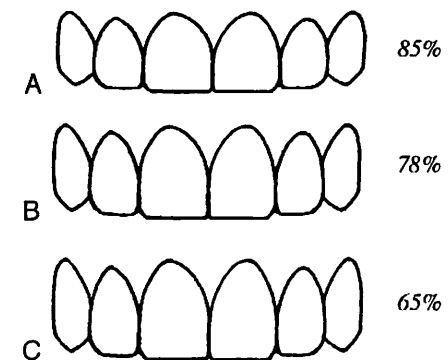
Another important proportion that needs to be evaluated is the width-to-height ratio of the central incisor. The preferred width-to-height ratio of the central incisor has been reported to be in the range of 66% to 80%.² Mold guides from a denture manufacturer reveal a central incisor with a mean width-to-height ratio of 78%. A width-to-height ratio of 78% has been determined to be the most pleasing to the author. Figure 6 illustrates three anterior tooth displays using different width-to-height ratios. Figure 6A shows an 85% width-to-height ratio, which gives a square appearance. Figure 6B fits into the more normal ratio cited earlier. Figure 6C shows a 65% width-to-height ratio, which makes the teeth appear taller. A tall person would be more likely to be able to use a smaller width-to-height ratio, and a short person would be more likely to be able to use a larger width-to-height ratio.

USE OF DENTAL PHOTOGRAPHY

Dental photography is essential in evaluating a smile. Photographs provide unlimited time as well as the ability to measure the dimensions and proportions of the teeth. An image taken parallel to the facial plane and at least 8 inches away from the teeth should be used to minimize distortion. The camera lens is not parallel to the entire facial plane but only to the front two teeth and gives a perspective view. If the camera is located too close, the teeth are distorted. A 35-mm camera with a 100-mm macro-lens set at 1:2 magnification is preferred. A digital camera with similar optical capabilities also may be used. It is important to use a high-quality camera, which gives adequate depth of field, proper lighting, and minimal optical distortion.

FACIAL IMAGE VIEW EVALUATION (FIVE)

The term used by the author to describe the use of a photograph to evaluate and measure the relative tooth dimensions of a smile is *facial image view evaluation (FIVE)*. A common dimension of a central incisor is measured first on the photograph and then on the cast. The cast dimension is divided by the image dimension to compute a *conversion factor*, which correlates the size of the image



to the actual size of the teeth. The height of the central incisor is preferred, but the width of the central incisor can be used if the gingival margin is not totally visible.

Proportional smile evaluations are based from the smile view as others see the patient, not from casts as dentists see teeth. Figure 7A shows how the widths of the teeth are determined when using a cast, and Figure 7B shows the resulting view of the anterior six teeth. Figure 7C shows how the widths of teeth are determined when using a frontal view, and Figure 7D gives the facial view of the front teeth. A single reference point in front of the smile is used to make a two-dimensional evaluation of the frontal plane of a three-dimensional smile. To determine properly the appropriate RED proportions of the widths of the teeth, a frontal view must be used.

The photographic image widths and heights of the anterior eight teeth are measured and recorded. The photographic measurements are multiplied by the conversion factor to give the FIVE dimensions. The further distal the dentist moves, the greater is the discrepancy between the FIVE and the cast dimensions. All applications of RED proportion use the FIVE view because an important part of the definition is "... as viewed from the frontal..."

USING FIVE DIMENSIONS TO EVALUATE RED PROPORTIONS AND WIDTH-TO-HEIGHT RATIOS

Once the FIVE dimensions have been calculated, the RED proportions and width-to-height ratios can be calculated easily. When using the RED proportion,

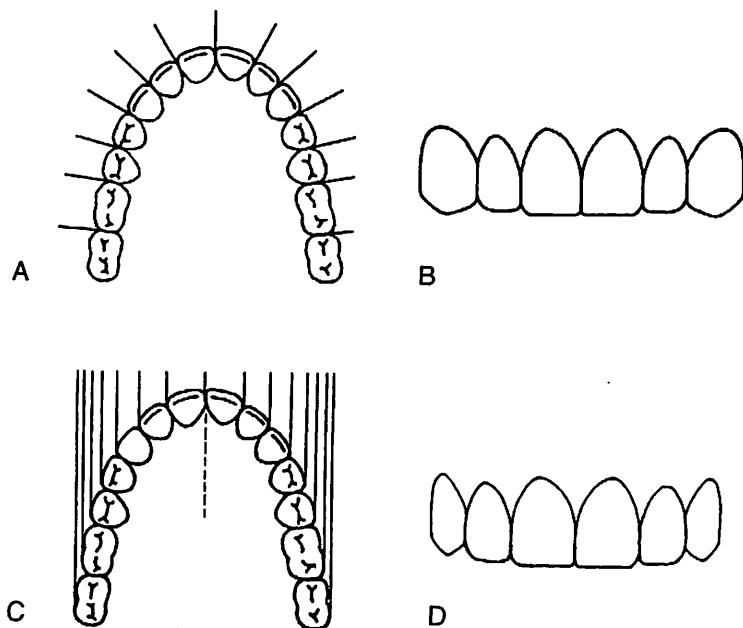


Figure 7. A, Cast tooth width. B, Resulting cast view width. C, Photographic tooth width. D, Resulting photographic view width.

the ratio or percentage of the successive widths of the teeth is being evaluated. The FIVE width of each successive distal tooth is divided by the FIVE width of the adjacent mesial tooth. The FIVE width of #5 (maxillary right first premolar) is divided by the FIVE width of #6 (maxillary right canine) giving a decimal or percentage that is recorded. The FIVE width of #6 is divided by the FIVE width of #7 and recorded. Subsequently the FIVE widths of #7/#8, #10/#9, #11/#10, and #12/#11 are calculated and recorded. According to RED smile design principles, the percentages should be similar. As discussed previously, a value of approximately 70% for each RED proportion is desired. The FIVE width of #8 is divided by the FIVE height of #8 and recorded. The FIVE width of #9 is divided by the FIVE height of #9 and recorded. A value of 78% is desired.

RED SMILE DESIGN

Through the combined use of RED proportion and width-to-height ratio, a powerful tool for smile design exists. Figure 8 shows the anterior six teeth with a constant width between the distal of the canines, a constant width-to-height ratio, and different RED proportions. A tremendous difference can be observed in the appearance of the teeth when the width-to-height ratio remains constant and only the RED proportion is changed. Figure 8A shows a RED proportion of 80%. Not only are the teeth more square, but also they become shorter. Figure 8C shows a RED proportion of 62% (golden proportion), in which the teeth become much taller to maintain the same width-to-height ratio. Figure 8B shows a RED proportion of 70%, which is preferred by the author.

When working with the anterior six teeth, mathematical formulas for calculating the ideal size of the central incisors may be used. The equation used to determine the ideal width of a central incisor from a predetermined RED proportion is:

$$\frac{(\text{FIVE width of the anterior 6 teeth})}{2(1 + \text{RED} + \text{RED}^2)} = \text{Width of central incisor}$$

(The RED should be expressed as a decimal < 1.)

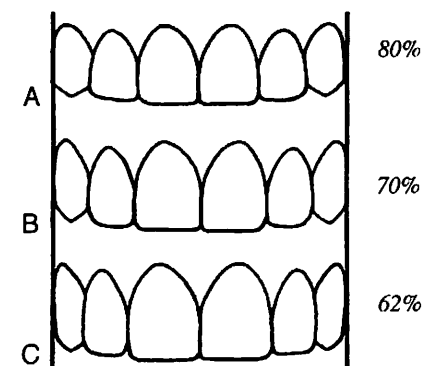


Figure 8. Different RED proportions with constant width of anterior six teeth and constant width-to-height ratio of central incisors.

Once the width of the central incisor has been established, the height can be determined by using the formula:

$$\frac{\text{Width of central incisor}}{\text{Width-to-height ratio}} = \text{Height of central incisor}$$

(The width-to-height ratio should be expressed as a decimal < 1.)

The anterior six teeth are the only teeth clinically in which the individual mesial and distal FIVE dimensions of the teeth can be altered significantly by making changes in the widths of the existing teeth. Because all evaluations are done using the facial image view, the FIVE widths of the premolars and molars are modified more easily by altering the buccal widths. For this reason, dentists do not use a formula for determining the ideal width of the central incisor to include the width of more than the anterior six teeth.

Case Presentation Using FIVE

Step 1: Obtain Image. A 21-year-old woman presented with two failing resin-retained fixed partial dentures. She was congenitally missing both maxillary lateral incisors. Severe lingual decay approximating the pulp chamber under the framework core of both central incisors was observed. Preoperative photographs were taken using a standardized protocol. The 1:2 smile is shown in Figure 9A.

Step 2: Complete the Measurement Worksheet. The height of the central incisor was measured on the cast of the patient with a Boley gauge, then on the photograph (Fig. 9B). A conversion factor was calculated relating the size of the tooth on the cast to the size of the tooth represented on the photograph (Fig. 10A). The height and the width of the anterior eight teeth were measured on the photograph and recorded (Fig. 10B). The use of a spreadsheet was invaluable to simplify and speed up the calculations. The computer was programmed to multiply the measured photographic dimensions by the conversion factor, then to display these calculated FIVE dimensions (Fig. 10C). The computer divided the FIVE width of the central incisor by its height to give a width-to-height ratio of each central incisor (Fig. 10D). The computer divided the FIVE width of each tooth by the FIVE width of the adjacent mesial tooth to determine the RED proportions (see Fig. 10E).

Step 3: Determine Incisal Edge. The starting point for any smile design using the RED proportion is the incisal edge. There are three determinants of

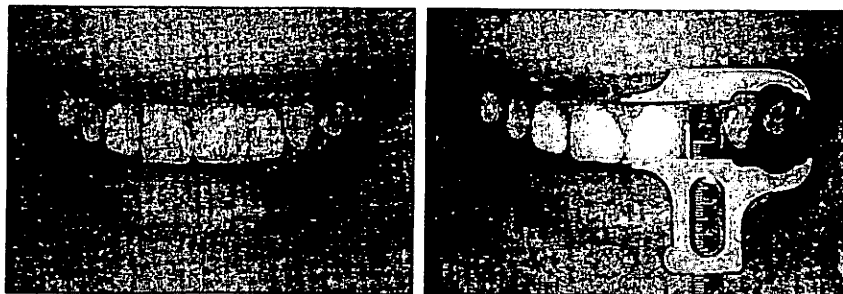


Figure 9. A, Preoperative view. B, Measurement using Boley gauge.

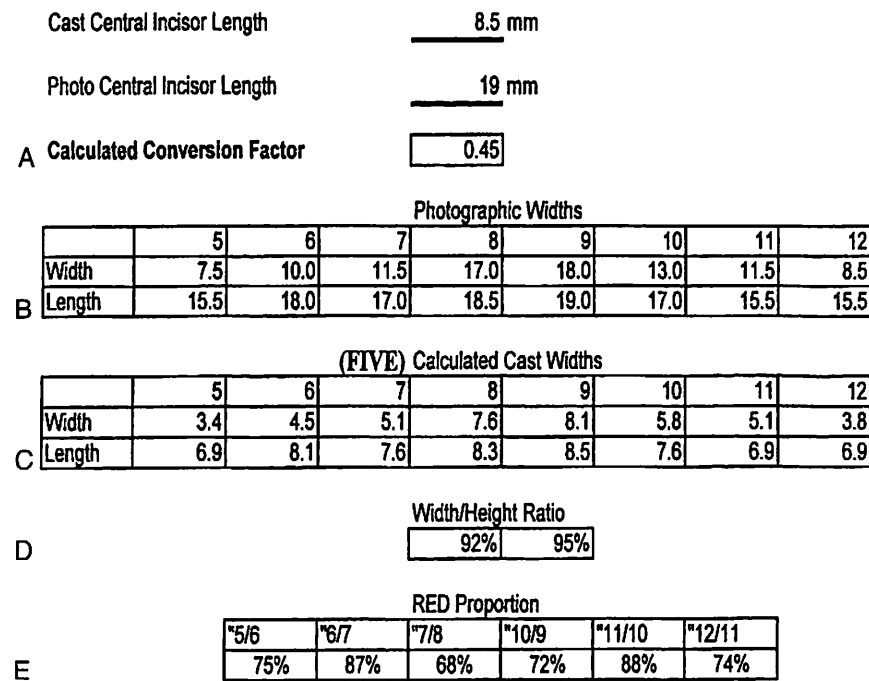
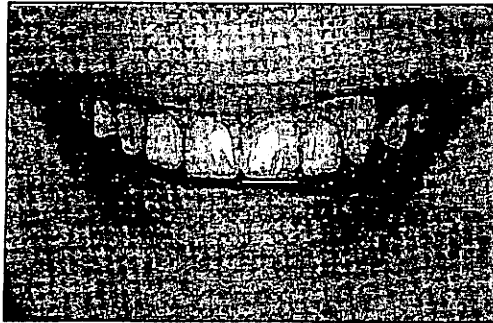


Figure 10. Measurement worksheet.

incisal edge position. The first determinant is esthetics. Ideally the incisal edge should approximate the contours of the lower lip during a smile.¹¹ The second determinant is phonetics. The *f* and *v* sounds should be used to determine the superior/inferior length of the incisal edge.¹⁰ The incisal edges should contact the junction of the wet and dry lines of the lower lips. The *th* sound should sound appropriate when speaking. The third determinant is anterior guidance and occlusion. Incisal guidance has not been given the importance it deserves.⁷ This determinant is important for the long-term stability of the case. Figure 11A shows the desired incisal edge position, which was determined to be 0.5 mm longer than the original position.

Step 4: Evaluate RED Proportion and Width-to-Height Ratio. The width-to-height ratios of the central incisors were too large with values greater than 90% and the ideal ratio being 78%. The computed RED proportions were inconsistent. The canines were too wide compared with the laterals. Using the computer with the above-stated equations, the dentist can test different RED proportions and different width-to-height ratios to calculate the optimal FIVE dimensions for the anterior teeth. By plugging in a desired RED proportion of 70%, ideal tooth widths were calculated. The use of a computer spreadsheet allowed experimentation with different RED proportions and width-to-height ratios to determine a reasonable and appropriate result. Using a 70% RED proportion and a width-to-height ratio of 79%, central incisors that were 10.5



(FIVE) Optimal Cast Widths

	5	6	7	8	9	10	11	12
Width	2.8	4.1	5.8	8.3	8.3	5.8	4.1	2.8
Length			9.5	10.5	10.5	9.5		

Width/Height Ratio

79%	79%
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RED Proportion

⁵ / ₆	⁶ / ₇	⁷ / ₈	¹⁰ / ₉	¹¹ / ₁₀	¹² / ₁₁
70%	70%	70%	70%	70%	70%

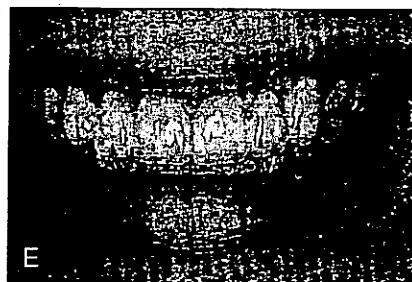
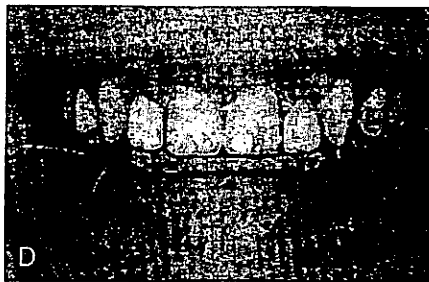
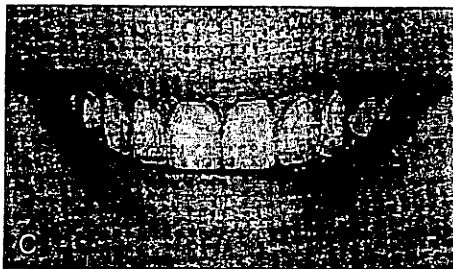


Figure 11. A, Desired position of incisal edge. B, Completed measurement worksheet with desired FIVE dimensions. C, Computer imaged photograph of desired postoperative smile using photographic widths converted from desired FIVE dimensions. D, Three weeks postperiodontal surgery. E, Post-treatment smile.

mm in height were calculated, which was judged to be clinically acceptable. Figure 11B shows the completed worksheet with desired tooth dimensions.

Step 5: Determine Treatment and Create Computerized Image. Conventional fixed dentures were indicated because of severe lingual decay of both central incisors, resulting in endodontic therapy and loss of significant tooth structure. Concomitant periodontal crown lengthening was determined to be the appropriate treatment to achieve the above-stated desired RED proportions and width-to-height ratios. The values of the optimal FIVE widths were divided by the conversion factor. This equation reverts the dimensions back to photographic sizes and allows the imaging of the desired smile (see Fig. 11C).

The patient was referred for periodontal crown lengthening. The specialist was given an image of the desired result along with actual desired final tooth dimensions. Using basic concepts of biologic width, periodontal surgery was performed. Figure 11D shows the 3-week postoperative view. The periodontium was allowed to heal for 3 months before final preparation, and fixed partial dentures subsequently were fabricated and inserted. Figure 11E shows the final result. The use of mathematical evaluation of the relative tooth dimensions was invaluable in obtaining a satisfying result.

SUMMARY

Dentists have needed an objective way in which to evaluate a smile. A method for determining the ideal size and position of the anterior teeth has been presented here. Use of the FIVE to evaluate the RED proportion and the width-to-height ratio, tempered with sound clinical judgment, gives pleasing and consistent results. With the diversity that exists in nature, rarely does the final result follow all the mathematical rules of proportional smile design. This approach may serve as a foundation on which to base initial smile design, however. When one begins to understand the relationship between beauty, mathematics, and the surrounding world, one begins to appreciate their interdependence.

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SHADES OF A COLOR

Illusion Or Reality?

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Esthetics in dentistry requires the artistic skill of balancing illusion with reality. This balance is called the *perception*—the aspect concerned with visualization of the appearance. The shades of teeth vary in different light conditions. The nature of the substance of enamel and dentin and the color of the gingiva influence the ultimate color of the teeth. When restorations are done, some look great, whereas others appear unattractive, even though the work was technically good. The difference between success and failure in esthetic restorations depends on many factors that affect the perception. When these factors are understood properly, they can help in creating clinically and esthetically acceptable restorations that blend with the shade of the enamel and the dentin.

In esthetic dentistry, the focus is on merging function and beauty with the values and the individual needs of the patient. Esthetic dentistry involves an attitude, artistic ability, intuition, and technical competence. The esthetic sense of a dentist is the ability to see the unseen with the third eye—the *mind's eye*. The ultimate objective is to create a beautiful smile, not just beautiful teeth but teeth of pleasing inherent proportions to one another and a pleasing tooth arrangement in harmony with the gingiva, lips, and face of the patient. It is necessary to view the treatment from an artist's perspective and acquire the ability to see the unseen through a systematic approach of evaluating, diagnosing, and creating esthetic results. Attaining the highest level of success in the creation of esthetic restorations necessitates understanding of the principles of illusion and their relation to clinical esthetics.

Illusion is the art of changing the perception of an object to appear different from what it is. Illusion is a combination of *illumination* and *vision*; there can be no illusion without illumination and vision. Likewise, there can be no esthetics without illusion. Illusions about size, shape, and color can be created to solve or

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