

Using the RED Proportion to Engineer the Perfect Smile



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Dentists have considered smile design to be a subjective process. Methods using ideal smile proportions and relationships have been described, but many have viewed these as too complicated and taking away from the artistry of dentistry. Simplified methods of proportional smile design need to be developed to allow more widespread application.

GOLDEN PROPORTION

The golden proportion has been discussed for centuries when describing body proportions. Due to unique mathematical properties, the golden proportion has taken on certain “mythical” or “magical” qualities. Leonardo da Vinci published drawings based on this 0.618:1 or 62% proportion between body parts. Its use in smile design was described by Levin, who stated the width of the maxillary lateral incisor should be in golden proportion to the width of the central incisor as viewed from the frontal.¹ The width of the canine as viewed from the frontal should be 62% of the width of the lateral incisor. The resulting central incisors are dominant, occupying 50% of the inter-canine width (Figure 1).

The ability to change the proportions of the teeth to suit the individual patient’s face, bone structure, or general physical type is important.

RED PROPORTION

A proportional smile design theory has recently been developed that may have a more universal application. The ability to change the proportions of the teeth to suit the individual patient’s face, bone structure, or general physical type is important.² The recurring esthetic dental (RED) proportion states the following: the width proportion between 2 adjacent teeth as viewed from the frontal should remain constant, progressing successively distally.³ Dividing the frontal view width of the maxillary lateral incisor by the frontal view width of the central incisor yields a quotient that should be the same as the quotient obtained by dividing

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Figure 1. Computer-imaged smile with tall teeth demonstrating the golden proportion.

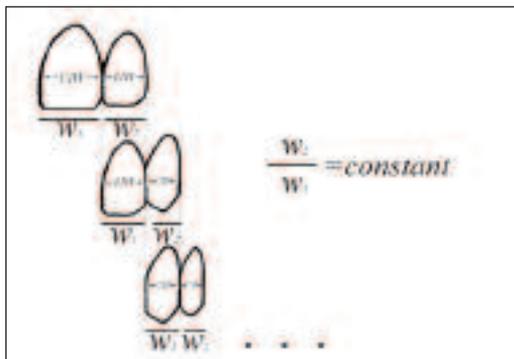


Figure 2. Principles of RED proportion.

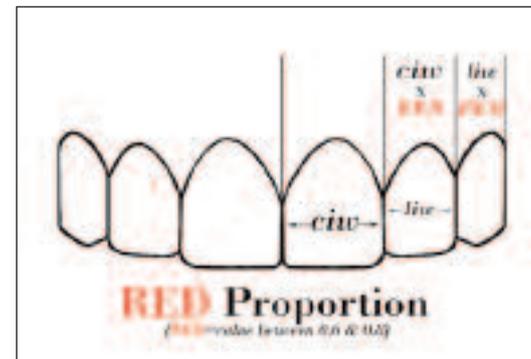


Figure 3. Graphic of RED proportion.

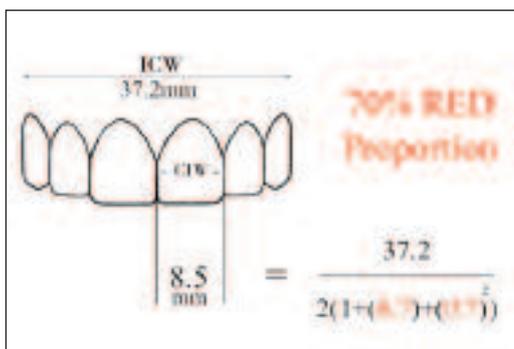


Figure 4. Calculating CIW from ICW with 70% RED proportion.

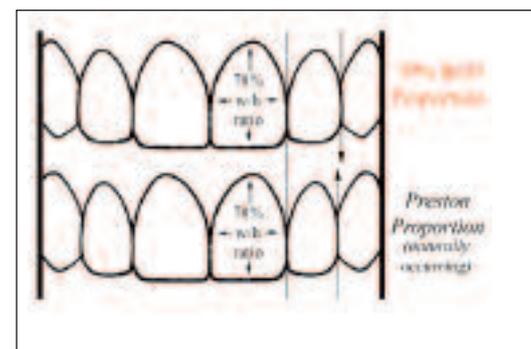


Figure 5. Graphic of 70% RED and Preston proportions.

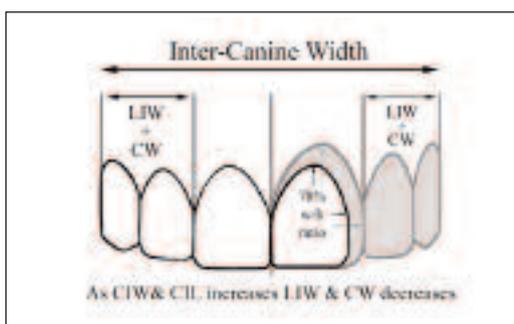


Figure 6. Taller CI gives narrower LI and canine.

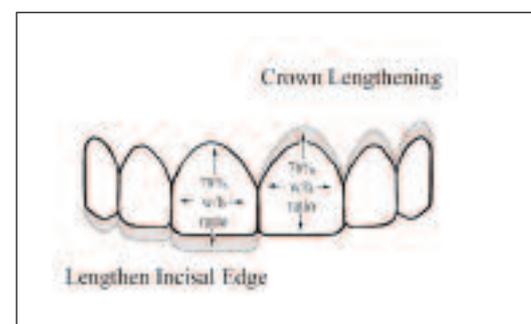


Figure 7. Methods to increase height to obtain 78% central incisor width-to-height ratio.

Using the RED Proportion...

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the frontal view width of the maxillary canine by the frontal view width of the lateral incisor (Figure 2). The RED proportion is not limited to one particular proportion but allows the desired RED proportion to be selected and consistently applied throughout each individual case (Figure 3). The golden proportion could be defined as the 62% RED proportion, and is one of many RED proportions that can be applied. Generally the values of the RED proportions used are between 60% and 80%. Once the ideal size of the central incisor has been calculated, the width of the central incisor is multiplied by the desired RED proportion to determine the frontal view width of the lateral incisor. The resulting lateral incisor width is multiplied by the same RED proportion to yield the desired frontal view width of the canine.

A mathematical formula has been derived that calculates the

width of the maxillary central incisor for any RED proportion given a fixed intercanine frontal view width. This width is determined by measuring the frontal view width between the distal aspects of the 2 maxillary canine teeth. The formula is as follows:

$(\text{frontal view width of the anterior 6 teeth}) / 2(1 + \text{RED} + \text{RED}^2) = \text{width of central incisor}$

The RED is expressed as a decimal less than 1. The RED proportion for average-length maxillary teeth has been defined as 70%. Using this formula, if the frontal inter-canine view width of the maxillary anterior 6 teeth is 37.2 mm and the desired RED is 70%, the calculated width of the central incisor would be 8.5 mm (Figure 4).

NATURALLY OCCURRING VERSUS PREFERRED PROPORTIONS

The golden proportion and RED proportion have not been readily observed in nature.^{4,5} A broad range of individual tooth widths occur within the population.⁶ In a study of

North American dental students Preston reported that the width of the average maxillary lateral incisor was 66% of the frontal view width of the central incisor.⁷ The width of the average canine was 84% of the frontal view width of the lateral incisor. Other studies have reported similar results.⁸ The central incisors are identical in size in both the Preston⁷ and 70% RED proportions. The lateral incisors are slightly wider in the 70% RED proportion, while the canines are slightly wider in the Preston proportion (Figure 5).

The golden proportion was not found to exist among individuals who were deemed to have an aesthetically pleasing smile.⁹ A recently published study¹⁰ found that a majority of surveyed dentists preferred the RED proportion in normal-length teeth to the golden proportion and the naturally occurring proportion described by Preston.⁷

CORRELATION OF TOOTH HEIGHT AND RED PROPORTION

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ed the relationship between the relative height of the teeth and the preferred RED proportion.¹¹ According to the study, a majority of surveyed dentists preferred the 80% RED proportion with smiles exhibiting short or very short teeth and the 62% RED proportion with very tall teeth. The dentists preferred the central incisors of the 70% RED proportion

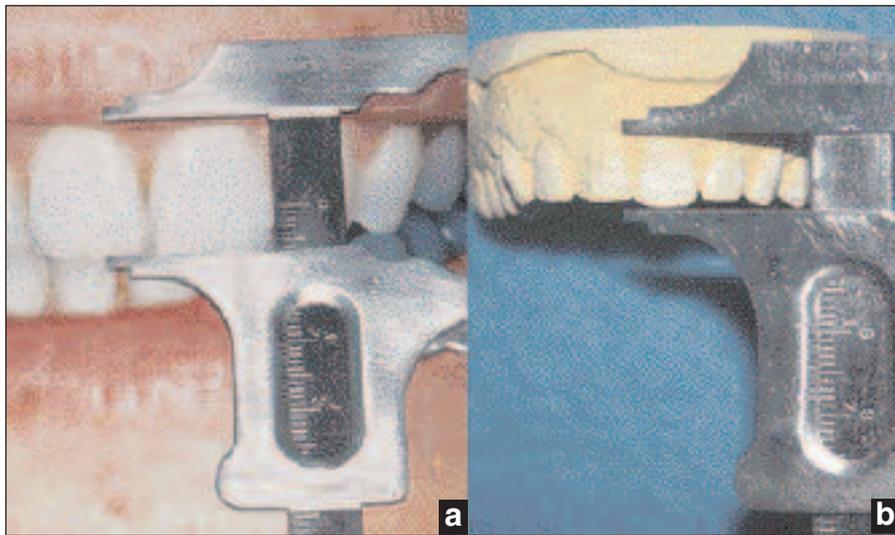


Figure 8. Boley Gauge measuring the same dimension on photograph (a) as on the cast (b).

Photo Central Incisor Length	19.1		Cast Central Incisor Length	9.2				
Calculated Cast/Photo Proportion	0.429319							
Photographic Widths								
	5	6	7	8	9	10	11	12
Width	3.0	7.4	11.0	17.0	17.0	11.0	7.5	4.5
Length	10.4	15.6	16.5	19.1	21.0	17.0	16.5	13.0
Calculated Cast Widths								
	5	6	7	8	9	10	11	12
Width	1.3	3.2	4.7	7.3	7.3	4.7	3.3	1.9
Length	4.5	6.7	7.1	8.2	9.0	7.3	7.1	5.6
Width/Height Ratio								
	89%		81%					
RED Proportion								
	5/6	5/7	7/8	10/9	11/10	12/11		
	41%	67%	65%	65%	69%	69%		
Desired RED (as a fraction)	0.7		Desired Width/Height Ratio (as a fraction)	0.78				
Optimal Cast Widths								
	5	6	7	8	9	10	11	12
Width	2.4	3.4	4.9	7.0	7.0	4.9	3.4	2.4
Length			7.9	8.9	8.9	7.9		

Figure 9. RED spreadsheet.

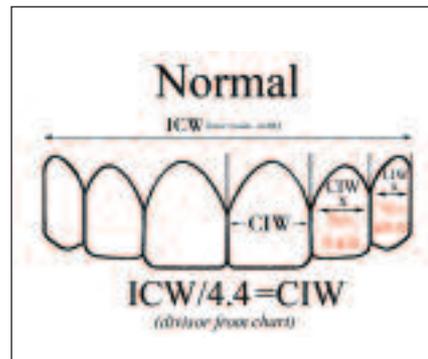


Figure 10a. Calculating normal CIW from ICW.

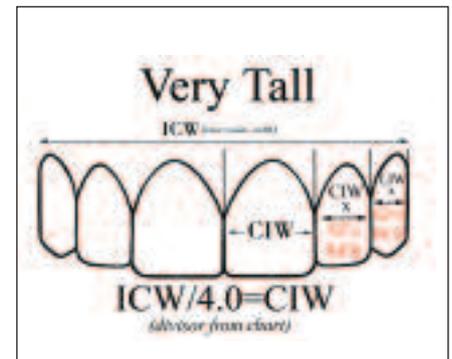


Figure 10b. Calculating very tall CIW from ICW.

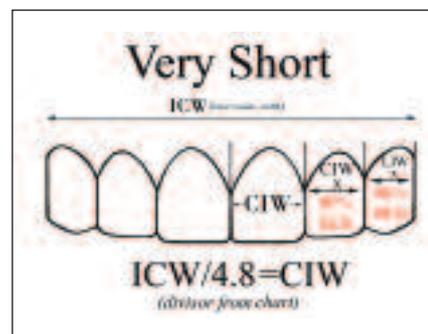


Figure 10c. Calculating very short CIW from ICW.

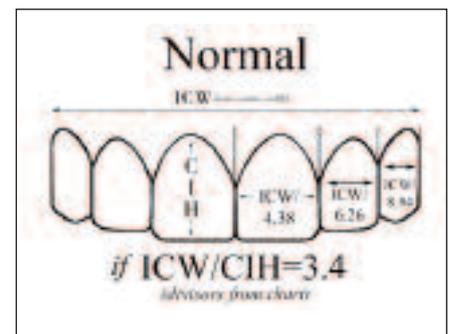


Figure 11a. Calculating normal CIW from ICW-CIH.

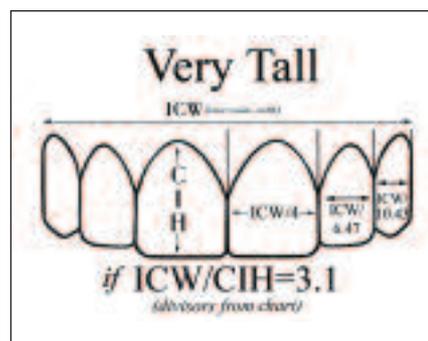


Figure 11b. Calculating very tall CIW from ICW-CIH.

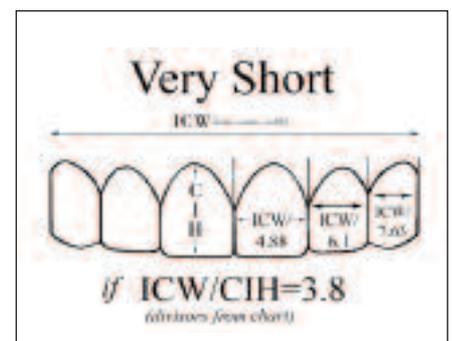


Figure 11c. Calculating very short CIW from ICW-CIH.

when viewing normal-length teeth. Smiles that maintained the 75% to 78% width-to-height ratio of the central incisor were preferred. From the study it appears that the taller the central incisor, the wider the size of the preferred central incisor, and the smaller the desired RED proportion. In practical terms, taller maxillary central incisors must be wider to maintain this favored width-to-height ratio. The result is a more dominant maxillary central incisor. This may help to explain why the golden proportion is often preferred when designing smiles for tall models.

If the resulting widths of the central incisors become wider in tall teeth in order to maintain the preferred 78% width-to-height ratio, less width remains available for the widths of the lateral incisors and canines (Figure 6). The widths of the teeth progressing distally become a smaller percentage of the previous tooth, and hence the RED proportion used is smaller in value. Several RED proportions may be considered when designing a smile. If the teeth are relatively short and the patient will not allow a change in length, a larger RED should be used. When there are no possible changes to the widths of the central incisors, the heights may be altered either by lengthening the incisal edges or performing elective periodontal crown lengthening surgery (Figure 7). The final length of the teeth and RED proportion used should ideally coincide with the patient's facial and body structure.

SIMPLIFIED USE OF THE RED PROPORTION

Original applications of the RED proportion used a computer spreadsheet to evaluate and determine the ideal sizes of the maxillary anterior teeth. A full-smile (1:2) photograph parallel to the facial surfaces of the anterior teeth was exposed, and the widths and heights of the maxillary anterior teeth on the photograph were measured and recorded (Figure 8a). A measurement common to both the photograph and the actual smile was used to correlate the fractional relationship between the dis-

played sizes on the photograph and the actual sizes of the teeth (Figure 8b). The photographic measurements were multiplied by the calculated fractional relationship to determine the actual facial view tooth dimensions. From these values

the width-to-height ratio of the maxillary central incisors and the proportions between the successive facial view widths of the anterior teeth were calculated (Figure 9). The width-to-height ratio of the maxillary central incisors and the succes-

sive width proportions (RED proportion) of the anterior teeth were input into the computer, which calculated the optimal cast width of the maxillary anterior teeth.

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Figure 12. Pretreatment smile.

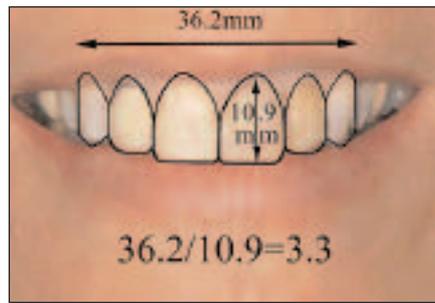


Figure 13. Using ICW divided by CIH to determine RED proportion.

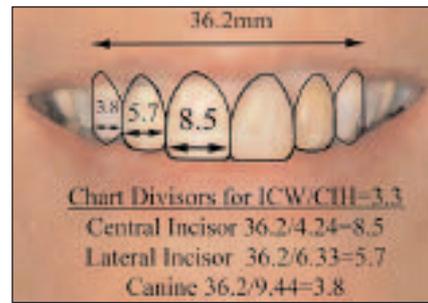


Figure 14. Using chart divisors to determine anterior tooth widths.

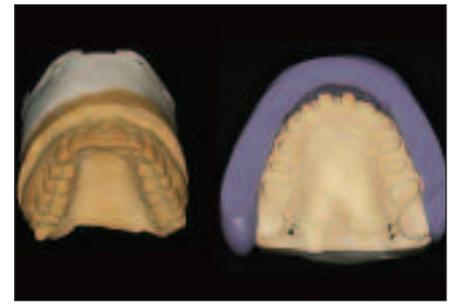


Figure 15. Mounted cast of provisional crowns and matrix used.

determine the ideal central incisor for different RED proportions simplifies the process. Table 1 displays the appropriate RED proportion and intercanine divisors. With normal-length maxillary central incisors, the frontal view intercanine width of the anterior 6 teeth is measured and divided by 4.4 (the value in the chart for normal-length teeth) to calculate the ideal width of the maxillary cen-

tral incisor. The width of the central incisor is then multiplied by 70% (the RED proportion in the chart recommended for normal-length teeth) to determine the width of the lateral incisor. The width of the lateral incisor is multiplied by 70% to determine the facial view width of the canine (Figure 10a).

With very tall teeth, the frontal view intercanine width of the anteri-

or 6 teeth is divided by 4.0 (the rounded value in the chart for very tall-length teeth) to calculate the ideal width of the central incisor, and the 62% RED proportion (as recommended by the chart) is used to calculate the frontal view widths of the lateral incisor and canine teeth (Figure 10b). With very short teeth the frontal view intercanine width of the anterior 6 teeth is divided by 4.8

(the rounded value in the chart for very short-length teeth) to calculate the ideal width of the central incisor, and the 80% RED proportion (as recommended by the chart) is used to calculate the frontal view widths of the lateral incisor and canine teeth (Figure 10c). Interpolations can be used for patients with medium-tall teeth or medium-short teeth to determine the desired widths and RED proportions (Table 1).

Table 1. Calculating RED and Anterior Total Widths From Intercanine Width (ICW) With Different Tooth Heights.

Tooth height	Desired RED proportion	Intercanine divisors (rounded) Central incisor width	Lateral incisor width	Canine width
Very tall	62%	ICW/4.0	CIW * 0.62	LIW * 0.62
Tall	66%	ICW/4.2	CIW * 0.66	LIW * 0.66
Normal	70%	ICW/4.4	CIW * 0.7	LIW * 0.7
Short	75%	ICW/4.6	CIW * 0.75	LIW * 0.75
Very short	80%	ICW/4.8	CIW * 0.8	LIW * 0.8

Table 2. Calculating RED and Individual Tooth Widths From Intercanine Width (ICW) and Central Incisor Height (CIH).

ICW/CIH	Appropriate RED proportion	Central incisor width	Intercanine divisors Lateral incisor width	Canine width
3.1	62%	ICW/4.00	ICW/6.47	ICW/10.43
3.2	65%	ICW/4.15	ICW/6.38	ICW/9.81
3.3	67%	ICW/4.24	ICW/6.33	ICW/9.44
3.4	70%	ICW/4.38	ICW/6.26	ICW/8.94
3.5	73%	ICW/4.53	ICW/6.20	ICW/8.49
3.6	75%	ICW/4.63	ICW/6.17	ICW/8.22
3.7	78%	ICW/4.78	ICW/6.12	ICW/7.85
3.8	80%	ICW/4.88	ICW/6.10	ICW/7.63

Table 3. Calculating RED and Individual Tooth Width Percentages of ICW From ICW and Central Incisor Height (CIH).

ICW/CIH	Appropriate RED proportion	Central incisor width (% of ICW)	Lateral incisor width (% of ICW)	Canine width (% of ICW)
3.1	62%	24.9%	15.5%	9.6%
3.2	65%	24.1%	15.7%	10.2%
3.3	67%	23.6%	15.8%	10.6%
3.4	70%	22.8%	16%	11.2%
3.5	73%	22.1%	16.1%	11.8%
3.6	75%	21.6%	16.2%	12.2%
3.7	78%	21%	16.3%	12.7%
3.8	80%	20.5%	16.4%	13.1%

CALCULATING IDEAL TOOTH WIDTHS

Pre-solving the equations for a 78% width-to-height ratio and substituting in the most common RED proportions further simplifies its use. Table 2 displays an alternative method of determining the appropriate facial view widths of the maxillary anterior 6 teeth. The intercanine width of the maxillary anterior 6 teeth is divided by the height of the maxillary central incisor. The quotient obtained is used to look up in the chart the appropriate RED proportion. The intercanine width is divided by the appropriate divisor to determine the facial view widths of the maxillary anterior 6 teeth. Figure 11a demonstrates calculation of the maxillary anterior 6 teeth for normal-length teeth where the intercanine width divided by the central incisor height equals 3.4. Figure 11b demonstrates calculation of the maxillary anterior 6 teeth for very tall-length teeth, where the intercanine width divided by the central incisor height equals 3.1. Figure 11c demonstrates calculation of the maxillary anterior 6 teeth for very short-length teeth, where the intercanine width divided by the central incisor height equals 3.8.

The intercanine width and appropriate maxillary central incisor length may also be used to determine the percentages of each anterior tooth of the frontal intercanine width (Table 3). These values are the reciprocals of Table 2. Please note for calculations that the selected RED proportion was the basis for all calculations and that all calculations have been rounded.

CLINICAL CASE

A patient presented desiring to make changes to her smile (Figure 12). A full series of photographs were taken, and diagnostic casts were made. The facial view intercanine width and the central incisor height were measured from the photograph to determine the relative proportion between them. It was determined that the intercanine width divided by the desired central incisor height was 3.3 (Figure 13). Reading the chart for 3.3, a 67% RED proportion was indicated. A template overlaid on the photo illustrates the desired proportions of the maxillary anterior 6 teeth (Figure 14). The desired central incisor width of 8.5 mm was determined by dividing the ICW (intercanine width) of the cast (36.2 mm) by 4.24. The lateral incisor width of 5.7 mm was determined by dividing the cast ICW by 6.33. The canine width of 3.8 mm was determined by dividing the cast ICW by 9.44. Twelve maxillary teeth were prepared, and the gingival heights were modified to create the desired lengths and outlines of the teeth. Provisional crowns were prepared using the calculated proportions and seated. Impressions were made of the prepared teeth and the provi-



Figure 16. Post-treatment smile.

sional crowns. A computer disc with a complete series of images and impressions was sent to the dental laboratory. The laboratory used mounted casts of the temporaries and fabricated a polyvinyl matrix of the temporaries in order to reproduce the size of the temporary crowns to the porcelain-fused-to-zirconia crowns (Figure 15). The finished crowns were tried in and seated (Figure 16).

CONCLUSION

The RED Proportion is an objective method of evaluating and designing smiles. A simplified technique to determine the ideal widths of the maxillary anterior teeth by measuring the facial view intercanine width

of the anterior 6 teeth and the height of the maxillary central incisor has been presented. Coordinating tooth heights with tooth widths should allow dentists and dental laboratories to determine pleasing proportional tooth sizes and lead to a better definition of an objective standard for smile design. ♦

Acknowledgment

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