A Biometric Approach to Predictable Treatment of Clinical Crown Discrepancies

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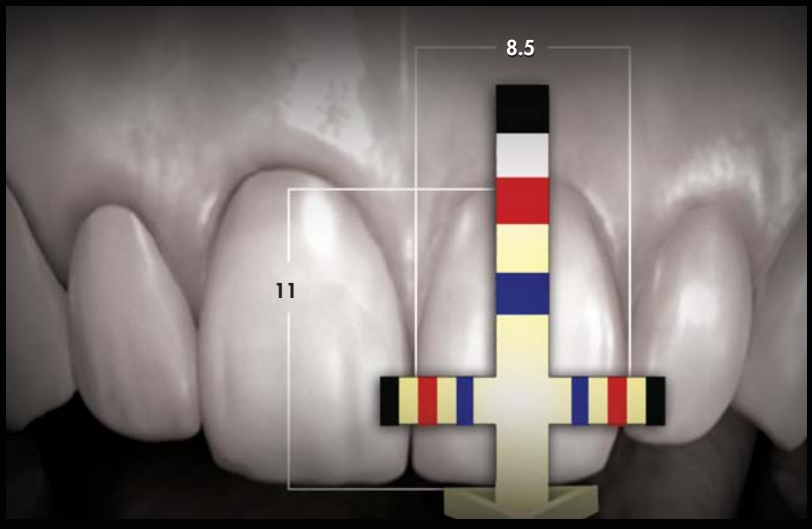

Dental professionals have long been guided by mathematical principles when interpreting aesthetic and tooth proportions for their patients. While many acknowledge that such principles are merely launch points for a smile design or reconstructive procedure, their existence appears to indicate practitioners' desire for predictable, objective, and reproducible means of achieving success in aesthetic dentistry. This article introduces innovative aesthetic measurement gauges as a means of objectively quantifying tooth size discrepancies and enabling the clinician to perform aesthetic restorative dentistry with success and predictability.

Learning Objectives:

This article discusses an approach for predictable diagnosis and correction of discrepancies in tooth size and individual tooth proportion. Upon reading this article, the reader should:

- Be able to quantatively evaluate aesthetic tooth dimensions.
- Recognize the benefits of measurement gauges in the development of proper individual tooth size.

Key Words: tooth proportion, dimension, size, gauge, biometric, aesthetics, maxillary anterior

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Dental professionals have long been guided by mathematical principles when interpreting aesthetic and tooth proportions for their patients. While many acknowledge that such principles are merely launch points for a smile design or reconstructive procedure, their very existence appears to indicate practitioners' desire for some predictable, objective, and reproducible means of achieving success in aesthetic dentistry.

The clinical reality, however, is that intra-arch tooth relationships used as guidelines for smile designs (eg, the Golden Proportion) are applicable to a confined segment of the patient population.[1] In addition, dentists have been found to be less pleased with aesthetic outcomes with smiles designed using the Golden Proportion,[2] and patients have been found to dislike such a proportion relationship.[3] Therefore the only tangible parameter in aesthetic dentistry is individual tooth size and proportion.[4,5]

Individual tooth size can be thought of as the building blocks of a smile design. Once the tooth size and proportion of the maxillary anterior teeth are corrected, they can then be arranged within the dental arch. Intra-arch tooth relationship proportions such as the recurring aesthetic dental proportion,[6] which has been found to be amenable to patients and clinicians, can be used to arrange the teeth for a pleasing smile.[6] This task is simplified in removable prosthodontics, in which selection of the proper tooth size and form is the primary step before their arrangement within the dental arch or tooth setup. With the natural dentition, this task is infinitely more difficult, since the dilemma is such that existing teeth may exhibit altered width and/or length discrepancies due to developmental anomalies, changes resulting from the aging process, or prior restorative procedures. Therefore, correction may require combination therapies such as orthodontics and/or periodontics prior to aesthetic restorative dentistry.

In daily practice, the clinician's use of "nonstandard" proportions to treat teeth with abnormal size relative to accepted width and height values can yield narrow or

Figure 1. Prototype proportion gauge; a Siamese twin instrument tip with preset markings notched into the surface with measurements indicating a predetermined 78% width to length proportion.

Figure 2. Surgical crown lengthening was provided additional clinical crown exposure; the proportion gauge was used to position the FGM of the soft tissue flap apicocoronally.

Figure 3. Preoperative smile of patient requiring aesthetic crown lengthening to restore proper individual tooth dimensions/proportion and decrease gingival display.

Figure 4. View of the smile after crown lengthening using the prototype gauge to predict the proper clinical crown length exposure.

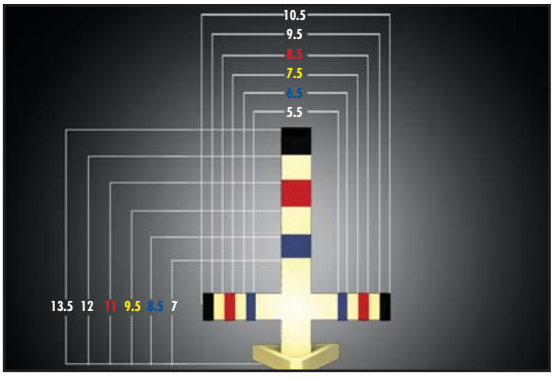

Figure 5. Diagram of T-Bar proportion gauge tip designed for simultaneous width and length measurements of maxillary anterior teeth within a range of small to extra large tooth dimensions.

square teeth that are unnatural in size and shape and fail to achieve the aesthetic expectations of either the patient or clinician. This can be particularly challenging when performed with visual assessment only (ie, absent of clinical tools). Standardized individual tooth size and proportions fall within a given range around mean values, however, and gender differences exist between anterior tooth groups.[7] Therefore, these parameters can be used to predictably diagnosis and correct discrepancies in tooth size and individual tooth proportion.

Historical Background

Traditionally, dental instruments (eg, explorers, probes) have been used as reference standards to detect diseases such as caries and periodontitis. Periodontitis is detected, evaluated, and assessed using numerical values indicative of health or stage of disease.[8-11] Instrumentation does not exist, however, to address aesthetic deformities from diagnosis to correction.

Aesthetic tooth dimensions can be evaluated and treated by similar numerical analysis. To test the application of these concepts, the author created prototype instruments. Metal wire (ie, 0.036 gauge) was soldered to form a Siamese twin instrument tip with preset markings notched into the surface with measurements indicating a 78% width (W) to length (L), proportion (Figure 1). Once the incisal edge position was established, the width of a tooth could be measured with the prototype instrument, and the notch on the long arm noted; then the corresponding notch on the long arm could be marked as the reference point for the new clinical crown length at a preset W/L ratio (Figures 2 through 4).

Revolutionary Instrumentation

Aesthetic measurement gauges (ie, Chu's Aesthetic Gauges, Hu-Friedy Inc, Chicago, IL), designed for diagnosis and correction of tooth size discrepancies and

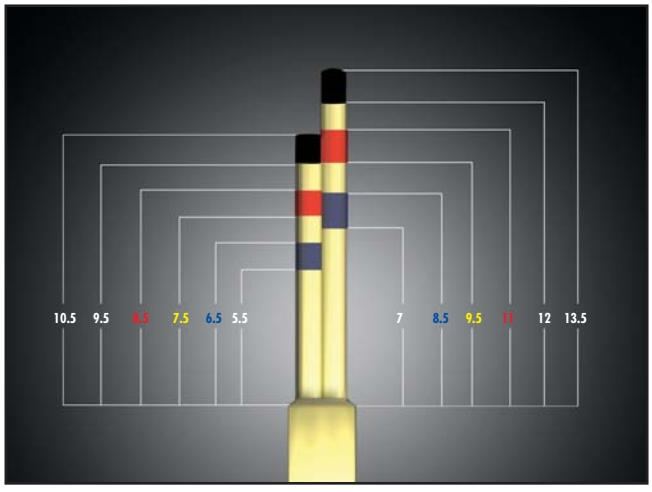

Figure 6. Representation of In-Line proportion gauge tip; it is used to measure widths and lengths of lateral incisors, canines, and central incisors independently when crowding is present.

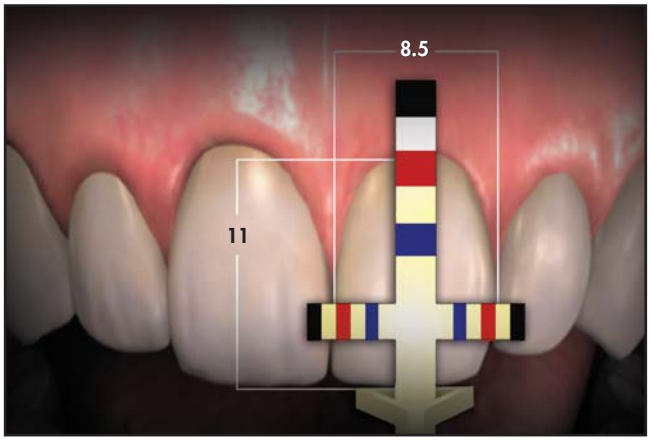

Figure 7. T-Bar tip utility; numbers and color bars on the horizontal axis correspond to those on the vertical axis, providing the clinician with a visual representation of optimal ITP.

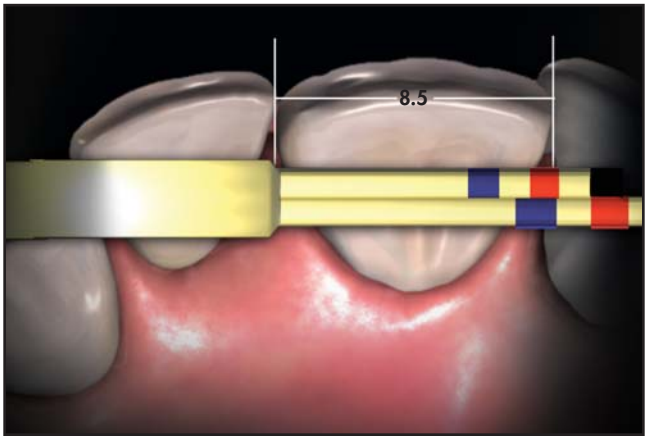

Figure 8. In-Line tip width utility; the short arm is aligned with the tip perpendicular to the long axis of the tooth to measure the width.

deformities, have been developed to eliminate the subjectivity associated with restorative care. These measurement tips include the ***Proportion Gauge (PG)***, which represents an objective mathematical appraisal of tooth size ranges. Through the use of such instrumentation, the clinician has a clearly visible means of applying aesthetic values to a patient chairside, directly or indirectly in the laboratory during projected treatment planning, and to objectively determine the intended treatment outcome.

The PG is designed as a double-ended instrument (ie, gauge) with a T-Bar and In-Line tip screwed into the handle at opposing ends. The T-Bar tip features an incisal edge position (ie, incisal stop); when a tooth is oriented with the tip accordingly, the practitioner can accurately evaluate its length (ie, vertical arm) and width (ie, horizontal arm) dimensions *simultaneously*. The width is indicated in equidistant 0.5-mm increments bilaterally, each with a vertical mark in a corresponding color (Figure 5). Thus, a central incisor with a "red" width of 8.5 mm will be in proper proportion if its height is also the "red" height (ie, 11 mm).

The In-Line tip is analogous to the metal prototype used in the aforementioned case study; the most significant difference being that the latter is a color-coded, plastic, disposable unit. The utility of the In-line gauge is

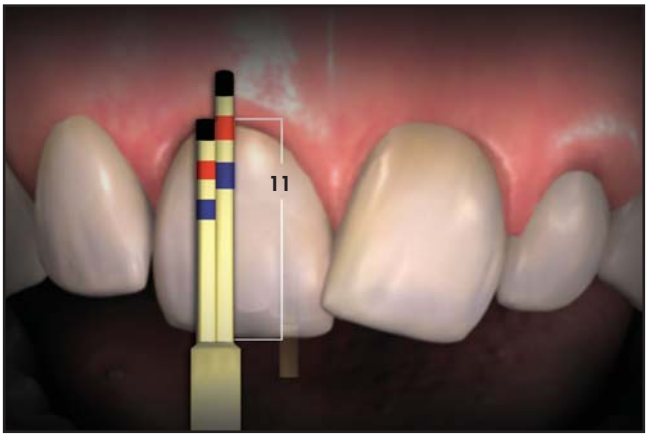

Figure 9. In-Line tip length utility; the corresponding red band on the long arm measures the clinical crown length. The outer blue bands and the intermediate yellow bands measure the lateral incisors and canines, respectively.

Figure 10. Preoperative condition of a patient requiring RSM for gingival recession, root hypersensitivity, and an unstable occlusal scheme.

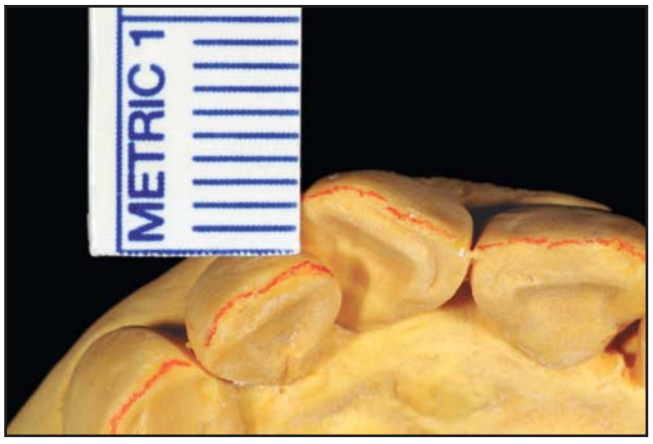

Figure 11. Diagnostic cast analysis reveals 3 mm of buccolingual and nearly 2 mm of mesiodistal space discrepancy.

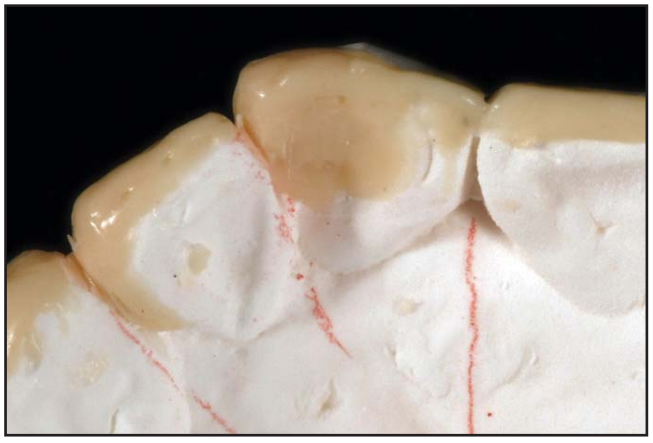

Figure 12. Diagnostic waxup showing correction of the BL/MD space discrepancies, thereby restoring proper width and proportion.

Figure 13. A silicone putty matrix was used to assess the proper facial and proximal tooth reduction required to correct the RSM discrepancies.

Figure 14. Provisional restorations provide valuable information on the projected aesthetic outcome from the case planning/waxup phase.

identical to the T-Bar tip, except for the fact that the horizontal arm of the T-Bar is now the short arm of the In-Line tip; the vertical arm and long arm of the tips are also the same. The short arm, at 1-mm increments, measures the tooth width, and the long arm measures the corresponding length at alternating 1.5-mm/1-mm increments, since the gauge is mathematically set at 78% W/L proportion. The black line at the base of the tip denotes the incisal guide, which is the starting point of measurement (Figure 6).

Should crown lengthening be necessary to achieve this result, the alternating 1.5-mm/1-mm increments marked on the vertical axis of the gauge yield predictable requirements for the increased vertical height of the gingival architecture complex.

Utility

These gauges enable clinicians to diagnosis and correct tooth size discrepancies. The present armamentarium for such diagnosis consists of manual and digital calipers, Bouley gauges, millimeter rulers, and periodontal probes. The gauges are designed to replace the present techniques, allowing simple diagnosis of tooth width and/or length problems as well as gingival length discrepancies.

The color-coded marks on the horizontal axis (ie, width portion) of the T-bar tip are aligned to the corresponding color markings on the vertical axis (ie, length portion) of the instrument. The numbers on the horizontal axis are organized from inside (ie, 5.5 mm) to outside (ie, 10.5 mm) in 1-mm bilateral increments (Figure 5). The numbers on the vertical axis are organized from bottom (ie, 7 mm) to the top (ie, 13.5 mm). The most common width/length numbers for the lateral (ie, blue), canine (ie, yellow), and central (ie, red) incisors are 6.5/8.5, 7.5/9.5, and 8.5/11 mm, respectively (Figure 7). The incisal edge position must be established before any gauges are used.

The In-Line proportion tool measures the width and length of the lateral, canine and central incisors *independently* when crowding is present (Figures 8 and 9). This instrument is color-coded similarly to the T-bar, with a preset width/length ratio of 78% and color-coded marks on the width portion aligned to the corresponding color markings on the length portion. The most common width/length numbers for the lateral (ie, blue), canine (ie, yellow), and central (ie, red) incisors are 6.5/8.5, 7.5/9.5, and 8.5/11 mm, respectively. The width is measured first and then the corresponding color-coded length is noted. There is an incisal guide to help position and orient the instrument during measurement.

Clinical Applications

Tooth size is a critical facet in aesthetics and has clinical relevance in restorative dentistry, orthodontics, periodontics, and implant dentistry. This is especially true and pertinent in the more complex restorative space management (RSM) case types, in which orthodontic therapy alone may be inadequate to address all the needs of the patient.[12] These measurement gauges (ie, Chu's Aesthetic Gauges, Hu-Friedy Inc, Chicago, IL) allow standardization of tooth size parameters,

Figure 15. The aesthetic restorative outcome is achieved through meticulous diagnosis, treatment planning, preparation matrices, laboratory fabrication, and final insertion.

Figure 16. The T-Bar proportion gauge tip is used throughout treatment to ensure the ITPs are optimized for a predictable aesthetic and functional outcome.

Figure 17. Preoperative appearance shows not only a high smile line, but also mild crowding, disproportionate tooth size and gingival harmony, and discoloration of the anterior dentition.

Figure 18. Measurement reveals a 10-mm–wide and 13-mm–long maxillary central incisor. The exterior red markings indicate the width/length of an average central incisor.

Figure 19. Orthodontic treatment goals were to align the dental arches and occlusal plane, retract the anterior teeth, close the gingival black triangles, and erupt #10 to decrease clinical crown length.

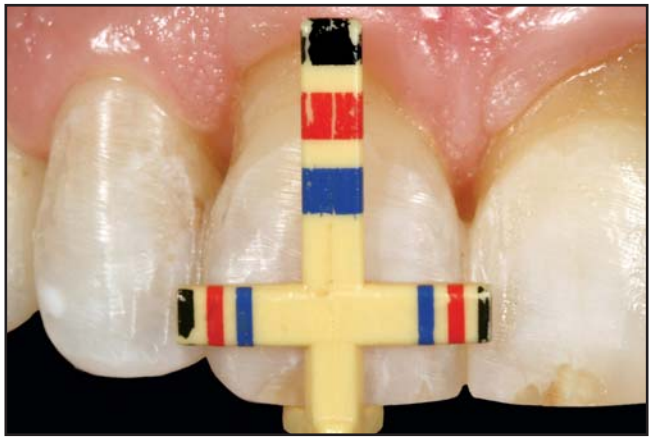

Figure 20. The proportion gauge is used during orthodontic therapy to objectively evaluate and visualize the projected ITP in conjunction with decreasing the interproximal gingival triangles.

as well as objective communication between clinicians and auxiliaries involved in comprehensive patient care from diagnosis (Figure 10), indirect case planning (Figures 11 and 12), treatment provisional restorations, and verification of tooth size correction to the final aesthetic restorative outcome (Figures 13 through 16).

Orthodontic therapy involves managing space discrepancies such as excessive or insufficient space due to tooth size and/or arch size discrepancies. Frequently, residual spaces are purposely fashioned to allow the restorative dentist to create the proper tooth size and form. Conversely, excessive space and/or tooth stucture can be condensed to provide the correct tooth size and proportion. Having measurement gauges that can guide the clinician in these RSM case types can lend to not only a stable occlusion, but also an aesthetically pleasing smile (Figures 17 through 24).

Aesthetic periodontal therapy demands addition and/or subtraction procedures in an effort to restore the proper tooth size and form. These gauges facilitate easy and quick diagnosis for addition (eg, grafting) or subtraction (eg, crown reduction) procedures to correct tooth size discrepancies.

Lastly, implant dentistry not only requires osseointegration for successful tooth replacement, but also edentulous ridge augmentation in order to provide enough hard and/or soft tissue to allow the proper tooth size to be established in the final aesthetic restorative outcome.

Conclusion

Human dental anatomy has not changed significantly in hundreds of years. Although dental and dental laboratory students are taught human dental anatomy and morphology in preclinical curriculum, practitioners often see dental restorations that do not exhibit the proper

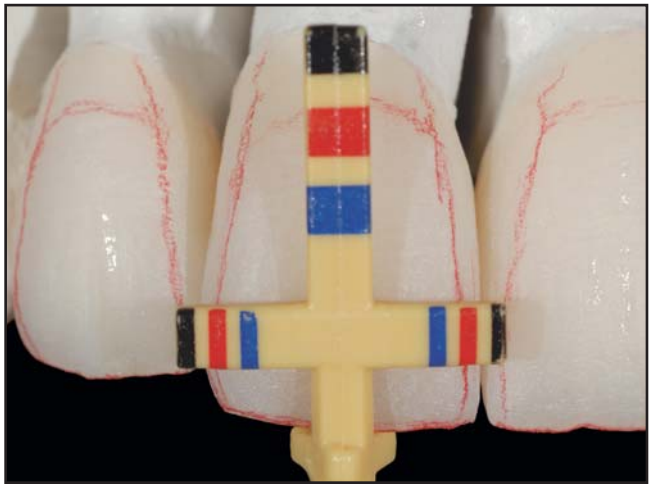

Figure 21. The proportion gauge was used in laboratory fabrication of restorations #7 through 11 within the preset 78% proportion ratio. The final tooth size was average to large in dimension while maintaining a pleasing ITP.

Figure 22. View of the restorations one week following insertion and cementation. The proportion gauge was used to visualize the final restorative outcome from diagnosis to implementation of treatment.

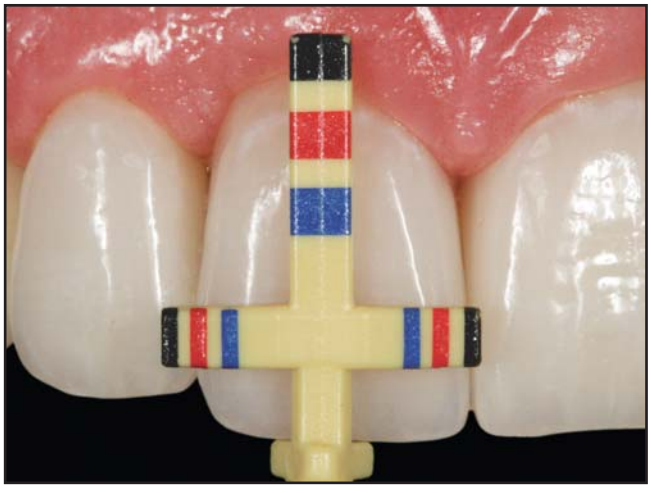

Figure 23. The final width of 9 mm and final length of 12 mm (ie, approximately 75%) was achieved using the proportion gauge as an objective visual marker during treatment.

Figure 24. View of the aesthetic restorative outcome with a clear vision of treatment objectives using innovative measurement gauges and meeting the patient's needs.

proportions of natural teeth. When visually essential aspects of dental anatomy and composition are not accurately incorporated into aesthetic restorations, patients are not completely served and practitioners may be frustrated as well.

The clinical examples depicted herein demonstrate the applicability of an aesthetic gauge system in maintaining anterior aesthetics for both standard and non-standard tooth sizes. When the tooth dimensions are maintained at 8.5 mm and 11 mm, a standardized length-to-width ratio can be developed. The aesthetic gauge can, however, be easily applied to non-standard tooth lengths (as demonstrated in the final clinical case), allowing the clinician to develop a harmonious proportion even when treating teeth with longer clinical crown lengths or widths. It is, therefore, the maintenance

of biometric proportions that will influence overall tooth harmony, particularly when treating teeth that fall outside of the traditional guidelines.

The creation and use of instruments such as these not only allows the restorative dentist to be an artist, giving expression to the restoration itself, but also provides the clinician with the opportunity to become an architect, incorporating numerical values of anatomic tooth dimensions and proportions into aesthetically pleasing smile makeovers. Thus, the new generation of aesthetic dentists will be architects and artists of the dentition.

Acknowledgment

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Continuing Education (CE) Exercise No. 13

To submit your CE Exercise answers, please use the answer sheet found within the CE Editorial Section of this issue and complete as follows: 1) Identify the article; 2) Place an X in the appropriate box for each question of each exercise; 3) Clip answer sheet from the page and mail it to the CE Department at Montage Media Corporation. For further instructions, please refer to the CE Editorial Section.

The 10 multiple-choice questions for this Continuing Education (CE) exercise are based on the article "A biometric approach to predictable treatment of clinical crown discrepancies," by Stephen J. Chu, DMD, MSD, CDT. This article is on Pages 401-409.

1. Which of the following is a potential disadvantage to usage of the Golden Proportion?
a. It is only applicable to a confined segment of the patient population.
b. Clinicians are often less satisfied with aesthetics resulting from the Golden Proportion usage.
c. Patients report being less satisfied with the results when clinicians apply the Golden Proportion
d. All of the above.

2. What is the width-to-length proportion the author applies to individual teeth?
a. 76%.
b. 77%.
c. 78%.
d. 79%.

3. According to the author, which of the following is considered the foundation of smile design?
a. Periodontium structure.
b. Individual tooth size.
c. Dental arch structure.
d. Proportion of mandibular maxillary teeth.

4. Which of the following is a factor that affects tooth proportion?
a. Developmental anomalies.
b. Age.
c. Gender.
d. All of the above.

5. The use of "nonstandard" proportions to treat teeth with an abnormal size relative to accepted width and height values often yields:
a. Aesthetically pleasing results.
b. Longer chairtime for the patient during treatment.
c. Unaesthetic, unnatural results.
d. b and c only.

6. RSM refers to:
a. Restorative space management.
b. Restorative space movement.
c. Restrictive space management.
d. Restrictive space movement.

7. What are the most common width-to-length measurements for canine incisors?
a. 8.5 mm to 11 mm.
b. 7.5 mm to 9.5 mm.
c. 6.5 mm to 8.5 mm.
d. 5.5 mm to 7.5 mm.

8. Why is tooth-size correction more difficult in natural dentition than in removable prosthodontics?
a. Teeth may exhibit width/length discrepancies.
b. Size correction can only be completed as the last step in restorative treatment.
c. There are no standard measurement gauges available.
d. Tooth-size correction is more difficult in removable prosthodontics than in natural dentition.

9. Which of the following instruments have been used as reference standards to diagnose and correct tooth size discrepancies?
a. Calipers.
b. Periodontal probes.
c. Millimeter rulers.
d. All of the above.

10. Which of the following must be established before any gauges are used?
a. Tooth length.
b. Tooth width.
c. Incisal edge.
d. The height of curvature.