Dental Anatomical Combinations: A Guide to Ultimate Dental Esthetics



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sthetic dental rehabilitation is an undoubtedly complex process. Numerous factors must be evaluated when designing a dental restoration, including tooth alignment, clinical crown dimensions, and occlusion. Complete understanding of all anatomical parameters is essential to create an esthetic and harmonious restoration.^{1–5} This article presents a new, simple system that will enable dental professionals to go beyond the usual creative standards in esthetic rehabilitation. First, the principal tooth forms and their characteristics will be analyzed. This discussion will lay the groundwork for the introduction of a new tooth form classification: Dental Anatomical Combinations. By sectioning the three principal tooth forms and recombining their individual characteristics, new tooth forms can be created. Finally, the application of this new system will be demonstrated via a clinical case report.

TOOTH ANATOMY

The Three Basic Tooth Forms

Various facial and dental forms exist in nature, and some researchers have proposed that these types should be the starting point for the rehabilitation of patients requiring a fixed or removable restoration.⁶⁻⁸

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Fig 3 Triangular tooth form.

Fig 1 Square tooth form.

Fig 2 Ovoid tooth form.

Many older studies examined the correlation between dental form and other factors, including sex,⁹ face form,^{10,11} shape of the maxillary arch,¹¹ constitutional type,¹² or personality.^{9,13} Even though these concepts have now been disproven,^{10,14–16} some professionals still consider these theories applicable to anterior restorations. However, it seems unlikely that such mathematical rules can provide a predictable outcome because they tend to detract from the creativity needed for a successful final result.^{17,18}

The literature shows that there are three basic tooth forms in nature: the square (type A), the ovoid (type B), and the triangular (type C)^{10,19,20}:

- Square: The mesial and distal proximal surfaces are parallel and perpendicular to the incisal edge and present a wide U-shaped cervical area. The vestibulodistal transitional ridge may be slightly curved, while the incisal edge is straight or slightly curved. The incisal edge is longer in the mesiodistal direction than that of the ovoid form and almost the same length as that of the triangular form (Fig 1).
- Ovoid: The incisal edge has a central protuberance; its length mesiodistally is the shortest of the three forms. The mesial and distal transition line angles are rounded and converge at the incisal and cervical areas. The U-shaped cervical line is more oval than in the square type (Fig 2).

 Triangular: The distal ridge is not parallel to the mesial ridge but rather markedly inclined, defining a very narrow V-shaped cervical zone with a convexity at the center of the crown. The incisal edge is wide mesiodistally and may have either a slight curve or convexity at the center. The incisal angles are slightly acute (Fig 3).

Tooth Outlines

During the design stage, all tooth forms must be evaluated from an incisal, cervical, and frontal view with a right-lateral and left-lateral projection (Fig 4). This evaluation will provide an overall sense of the tooth organization as well as the relationship between the anatomical parts (Figs 5 and 6).^{21,22}

The three principal tooth forms comprise numerous variations that include both the shape and form of the teeth.²³ In this context, the term "form" indicates all macrocharacteristics, such as the outline of the tooth, development of the ridge, depth of the grooves, and difference between the mesial and distal incisal angles.^{24,25} Microcharacteristics, ie, surface texture, also play an important role in the anatomical qualities of the tooth (Fig 4).

The physical form of a tooth is determined by its outline, comprising the incisal border, proximal ridges,









Fig 4 Outline of the tooth structure showing the position of the (*left*) vertical and (*right*) horizontal grooves and ridges.

Fig 5 Cervical views of the tooth form.

Fig 6 Tooth form viewed from the incisal area toward the cervical area.

Fig 7 Joining the transition lines through the tooth lobes. These lines define all characteristics of the tooth that will make it appear as a single body.

Fig 8 Surface torsion allows for individualization of the vestibulodistal lobes.

and cervical line. These lines dictate the path of the ridges and the shape of the lobes. Thus, the outline of the tooth should be evaluated before analyzing the tooth three-dimensionally.

Transition Lines

The characteristics of tooth form are not separate entities; rather, they combine to create a single feature. In other words, a tooth is crossed by grooves that determine the three-dimensional anatomical areas. A frontal view alone does not provide sufficient information to reproduce the area around a transition line. Thus,



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the operator should begin work on each transition line starting from the lingual surface. In all natural teeth, the ridges and grooves begin at the lingual surface and then connect to the proximal and vestibular surfaces (Fig 7).

Surface Torsion

Surface torsion is another important factor in the design of an artificial tooth. From an incisal view, distal protrusion becomes evident at the level of the cervix (Fig 8). Failure to consider this surface torsion may result in artificial incisors that appear flat or distally pro-



truded.²¹ The line of rotation starts from the vestibular aspect and continues lingually.

Torsion is common to all teeth, although to varying degrees of intensity. Surface torsion is gentler in the incisors and more pronounced in the canines; however, the technician may define the extent of torsion based on the desired tooth form. In more facially positioned teeth, surface torsion becomes more evident.

DENTAL ANATOMICAL COMBINATIONS

Based on the anatomical concepts discussed above, the authors now introduce a new tooth form classification system: Dental Anatomical Combinations. This simple concept aims to help dental professionals produce different tooth anatomies that extend beyond the standard tooth shapes.

The basic principle of this system is the segmentation and recombination of two or even all three of the basic tooth forms.²⁶ First, the perimeter of each tooth form is sectioned into smaller segments; for example, by sectioning the tooth into three different segments, a mesial, distal, and incisal segment can be obtained. If necessary, these full segments can be further divided in half, resulting in six half segments: mesial cervical, mesial body, mesial incisal, distal cervical, distal body, and distal incisal (Fig 9). To create the final tooth form, the full or half segments can be recombined, creating complementary classes (Table 1). The class numbering system (1:3, 1:2, 1/2:3, or 1/2:2) indicates which segment was used (number before the colon = full [1] or half [1/2] segment) and with how many basic tooth forms for recombination (number after the colon = 2 or 3 basic tooth forms).

The first complementary class, 1:3, uses one full segment of each of the three principal tooth forms, resulting in 6 different shape combinations (Fig 10). The second complementary class, 1:2, uses one full segment combined with two principal tooth forms. This results in 18 different tooth shapes (Figs 11 to 13). The third (Fig 14) and fourth (Figs 15 to 17) complementary classes, 1/2:3 and 1/2:2, involve half segments combined with 3 or 2 principal tooth shapes, respectively. By dividing the tooth vertically or obliquely into two parts, the segments are always in contrast with the final shape, giving the tooth a more dynamic appearance.

Although many anatomical combinations are possible mathematically, only a selection of them is shown here. In total, this article presents 48 anatomical tooth



lable 1	Dental Anatomical Combinations		
		Principal	Complementary
Segments		shapes	class
1		3	1:3
1		2	1:2
1/2		3	1/2:3
1/2		2	1/2:2



10b

Figs 10a and 10b Complementary class 1:3. Full tooth segments of all three basic tooth forms are combined with each other.



Copyrigh,





11b



12a









13b

Figs 11a and 11b Complementary class 1:2 ovoid-square combinations.Figs 12a and 12b Complementary class 1:2 square-triangular combinations.Figs 13a and 13b Complementary class 1:2 ovoid-triangular combinations.







15a

combinations. These combinations demonstrate new ways for clinicians and technicians to give artificial teeth a more dynamic appearance. Segmentation is a means of composition. In the laboratory, it represents a concrete visual message rather than an abstract one, thus allowing for better communication between the clinician and technician and enhanced production of the desired tooth forms.

COPYrio



15b



1**6**a



16b

Figs 14a and 14b Complementary class 1/2:3. Half segments of all three basic tooth forms are combined with each other. Many more combinations are possible than shown here.

Figs 15a and 15b Complementary class 1/2:2 triangular-ovoid combinations.

Figs 16a and 16b Complementary class 1/2:2 ovoid-square combinations.





17b

Figs 17a and 17b Complementary class 1/2:2 square-triangular combinations.

CASE REPORT

A 46-year-old male patient presented with concerns regarding the esthetics of his maxillary anterior dentition. His chief complaint was the diastemata between the central incisors and between the right central incisor and canine (Fig 18). Both maxillary lateral incisors were congenitally missing. When the patient was at a young age, orthodontic treatment had transposed his canines and premolars to substitute for the missing lateral incisors. However, the spaces between the anterior teeth had not been closed completely at that time; further, other than minimal enameloplasty, the transformation of the canines into lateral incisors had remained unfinished. The patient did not undergo additional orthodontic treatment. He requested an esthetic but minimally invasive treatment to preserve as much intact tooth structure as possible. The treatment plan comprised six veneers to restore the maxillary central incisors, canines, and first premolars.

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Figs 18a to 18g Preoperative situation. Note the diastemata and the incomplete transformation of the canines used to replace the congenitally missing lateral incisors.







19b



19c





19e





Figs 19a to 19g Fabrication of the diagnostic wax-up. (a) Initial situation. (b) Positioning of the ridges. (c) Waxing of the central ridge and incisal cones. (d to g) Reevaluation of the wax-up from a variety of angles.

19g

Diagnostic Wax-up

Prior to formulation of the treatment plan, impressions were taken to fabricate diagnostic casts and a diagnostic wax-up.²⁷ The diagnostic cast showed a triangular-ovoid tooth configuration of the maxillary incisors.²⁶ A 1/2:3 complementary class, combining all three principle tooth forms, was chosen for the wax-up to close the diastemata and redistribute the interproximal spaces more effectively. Beginning at the marginal ridges, the incisal cones and central ridge were waxed up, followed by the facial surface (Figs 19a to 19c).²⁷

During every stage of the process, the wax-up must be carefully evaluated from all dimensional aspects (Figs 19d to 19g). Once the facial surface was completed, surface characterization was carried out (Fig 20). Figures 21a to 21h show the finalized wax-up with successful transformation of the canines into lateral incisors and of the first premolars into canines. Figure 21i shows the central incisors with a 1/2:3 complementary class.

To transform the canines into lateral incisors, the differences between them in terms of overall shape, size, and anatomical features (eg, mesiodistal and orofacial









20b



21b

21e



20c



21c



21f



21h





21d

Figs 20a to 20c Surface characterization.

Figs 21a to 21i (*a to h*) Completed wax-up with transformation of the canines into lateral incisors. A squaretriangular shape was chosen. (*i*) Complementary class 1/2:3 applied to the wax-up.









canine in the cervical area.

be reduced to the size of a lateral incisor.

Figs 22a to 22c Measurement of the mesiodistal and orofacial width of the

Fig 23 To achieve an optimal cervical emergence profile, the canine had to





width) should be considered. Therefore, measurements of the canines were taken at the cervical areas. The canines had a mesiodistal and orofacial width of 7 mm (Fig 22), whereas a lateral incisor has a mean mesiodistal and orofacial width of approximately 5 mm.^{1,21,28} Thus, to create a cervical emergence profile that matches that of a lateral incisor, the canine had to be reduced in width to 5 mm (Fig 23). At the facial surface, the reduced convexity of a lateral incisor compared to a canine should also be taken into account. Insufficient preparation of the canine may result in either inadequate thickness of the ceramic or, if minimal thickness of the ceramic is maintained, in an overcontoured final restoration. At the same time, excessive preparation would conflict with the patient's desire for

minimally invasive treatment and, more importantly, compromise optimal bonding of the veneers by exposing the dentin. Considering these parameters, tooth preparation

Considering these parameters, tooth preparation was simulated in the laboratory (Fig 24). Such a simulation aids communication between the technician and dentist. Based on the simulation, silicone keys were fabricated (Fig 25) and delivered to the dentist as a preparation guide.²⁷ Further, the preparation simulation allowed for the fabrication of a provisional shell.









24c

Figs 24a and 24b Preoperative preparation simulation.

Figs 24c and 24d Silicone keys based on the diagnostic wax-up.

Fig 25 Silicone preparation guides.



24b



25

Tooth Preparation

The silicone guides were first used to verify the original dimensions of the teeth in relation to the projected tooth shape as outlined in the wax-up (Fig 26a). No preparation was necessary for the central incisors. Minimal preparation including only the facial surface was needed at the first premolars. The occlusal and lingual aspects of the first premolars remained untouched. For the canines, tooth preparation was performed as projected in the simulation. The incisal edge was reduced by 1 mm using diamond burs (Komet, Lemgo,

26c

26b

Fig 26a Intraoral verification of the difference between the wax-up and preoperative situation.

Fig 26b Interproximal reduction with a diamond bur.

Fig 26c Diamond wheel used for interproximal reduction. A gingival protector (not pictured) was used to protect the soft tissues.

Fig 26d Verification of the cervical width.

Fig 26e Final tooth preparation.

Germany), followed by a 1-mm reduction of the facial surface with a light chamfer at the cervical margin. The mesial and distal surfaces were each reduced by 1 mm using diamond burs, and diamond-coated disks (Komet) were used in the interproximal region to shape the cervical area to the desired width of 5 mm (Figs 26b to 26d). A gingival protector (Zekrya, DMG America, Englewood, New Jersey, USA) was used to retract and protect the soft tissues. Prior to impression taking, retraction cords without any hemostatic agent were placed (Fig 26e). A polyvinyl siloxane impression material (Extrude EXTRA and WASH, Kerr, Orange, California, USA) was used in conjunction with the double-mix technique to capture the preparations. The prepared teeth were provisionalized with the previously made provisional shell after relining.

27b

Fig 27a Soft tissue cast from the alveolar cast.

Fig 27b Alveolar cast with segmented dies.

Fig 27c Refractory dies on the alveolar cast.

Fig 27d Layering of feldspathic ceramic onto the refractory dies to build up the incisal wall and proximal aspect.

Fig 27e Completed ceramic layering.

Fig 27f Optimal adaptation of the intaglio surface to the master die.

Fig 27g Alveolar cast with the final restorations.

27c

Fabrication of the Ceramic Veneers

To fabricate the ceramic veneers, an alveolar cast consisting of an intact soft tissue cast and interchangeable dies was created (Figs 27a and 27b).²⁹ The presence of the soft tissues is crucial because they are central in the positioning of the transition lines and because they allow for better control over the tooth shape.^{17,18}

Feldspathic ceramic (Creation, Jensen, North Haven, Connecticut, USA) was layered to fabricate the veneers. The first step of the layering process was to apply two layers of connector material on the refractory dies with two different firings (Fig 27c). Next, various enamel and translucent masses were applied to build up the incisal wall (Fig 27d). Modifiers and stains were also added to obtain incisal effects; the mesial and distal aspects were built up in the same manner, followed by the first bake. The entire labial shape was then layered using 20 ceramic masses (Fig 27e).

After the next bake, the ceramic was ground with diamond burs to create the desired anatomical shape and texture. Glazing was performed to provide harmony between the restorations and adjacent natural teeth, and all veneers were manually polished.

The veneers were removed from the refractory dies via sandblasting with glass beads at low pressure. The veneers were then adapted to the master dies using a stereomicroscope at $\times 12$ and $\times 20$ magnification. For optimal adaption of the intaglio surfaces of the veneers, adjustments were initially performed at the finish line and peripheral areas, followed by the central areas (Fig 27f). Once adaptation was complete, the contact points were checked on the solid cast. It was determined that the veneers were ready for delivery (Figs 27g and 28).

28b

Fig 28a Definitive ceramic veneers.

Figs 28b to 28d Optimal marginal fit of the ceramic veneers on the master dies.

Try-in and Cementation

The provisional restorations were removed, and the teeth were cleaned using pumice. The definitive restorations were tried in to verify the fit, shape, and shade.

The intaglio surfaces of the feldspathic veneers were etched with 4.5% hydrochloric acid (IPS Ceramic Etching Gel, Ivoclar Vivadent, Schaan, Liechtenstein) for 1 minute (Fig 29a) to promote micromechanical retention by removing the glass matrix. This etching process produces crystalline precipitates that are insoluble in water (Fig 29b). The precipitates can be removed by either ultrasonic cleaning for 5 minutes or etching with 35% phosphoric acid (Ultraetch, Ultradent, South Jordan, Utah, USA) for 1 minute (Fig 29c). Failure to remove such residues may result in reduced bond strength to the ceramic intaglio surface.^{30,31} After rinsing and drying, a silane coupling agent (Porcelain

Silane, Premier Dental, Plymouth Meeting, Pennsylvania, USA) was applied for 2 minutes.

A light-cured nanofilled composite resin material (shade CT, Filtek Supreme Ultra, 3M ESPE, St Paul, Minnesota, USA) was used for cementation. In the oral cavity, the cement at the margins will be subjected to water sorption, subsurface degradation, wear, and discoloration.³² In comparison to methacrylate- or phosphate-based resin cements, preheated composite resins used as luting agents have been shown to exhibit reduced deterioration by wear.³² Cements with smaller filler particle size and higher filler load also showed less wear.^{33,34} Further, unlike self- or dual-curing cements, light-cured cements allow unlimited time for placement of the restoration and removal of excess cement.

For better handling during cementation, the highly viscous composite resin should be preheated. Heat-

ing the composite resin reduces viscosity, improves flowability, and decreases film thickness.³² However, once removed from the heating unit, the composite resin cools down quickly during handling and may cool even more rapidly if applied to a much colder restoration at room temperature, thus voiding the advantages of the preheating. Therefore, the restoration must be preheated as well. To avoid rapid temperature loss, the veneers were filled with a thin layer of the preheated composite resin (Fig 30a) and then placed into the heating unit until needed (Fig 30b).

The veneers were bonded one after another, beginning with the central incisors and proceeding to the canines and premolars. While the veneers were being

Fig 30a Thin layer of preheated composite resin applied to the intaglio surface of the veneer.

Fig 30b Placement of the composite resin–loaded veneers into the heater.

Fig 30c Light polymerization through a layer of glycerin gel.

Figs 31a to 31e Final result.

preheated, a total-etch adhesive system (Optibond FL, Kerr) was applied to each tooth but initially left uncured. After placement of the restoration on the designated tooth and removal of excess luting agent, light curing was performed for 40 seconds through a layer of glycerin gel to avoid the oxygen inhibited layer (Fig 30c). A scalpel and scaler were used to remove excess adhesive and luting cement. Interproximal areas were finished with polishing strips (Sof-Lex Finishing Strips, 3M ESPE), and occlusion was checked and adjusted. To complete the rehabilitation, the insufficient Class V restorations on the second premolars and first molars were replaced with nanohybrid composite resin restorations (ENA HRi, Synca, Le Gardeur, Quebec, Canada). Figure 31 shows the final result 2 months after delivery.

CONCLUSIONS

By creating different anatomical combinations of basic tooth forms, dental professionals can design a wide range of esthetic restorations. The proposed classification system—Dental Anatomical Combinations—will aid clinicians and technicians in the fabrication of harmonious and dynamic artificial teeth. Detailed treatment planning and careful communication between the dentist and laboratory are essential for a successful final result.

31b

<u>31</u>c

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