

## Three-Dimensional Management of Dental Proportions: A New Esthetic Principle—"The Frame of Reference"

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**E**sthetic dentistry is both science and art, and the science of it has considerably evolved in recent years. The artistic aspect, on the other hand, has remained unchanged and not well defined. The management of dental proportions has always presented a challenge, especially for cases whose reference lines must change. This difficult task is often delegated to the dental technician. However, both the dentist and the dental technician have to plan and carefully execute the implementation of the esthetic principles put forth in this article prior to making the final impression. Only then will the technician

be able to achieve a result that reflects the proposed changes.

This article will discuss the guidelines for the diagnosis and treatment of anterior teeth and will focus on the management of the dental proportions. The esthetic principle of the "frame of reference" will be presented.

### ARTISTIC AND SCIENTIFIC FUNDAMENTALS FOR ESTHETIC DENTISTRY

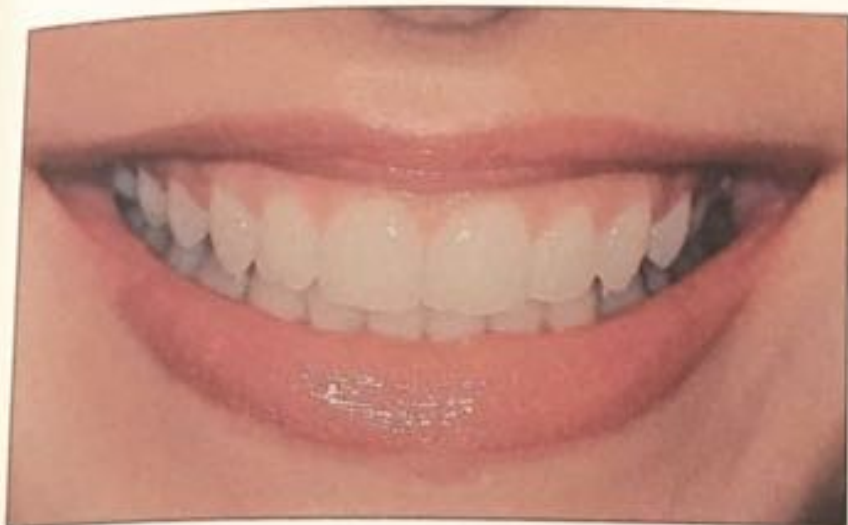
In dentistry, as in any art, there are certain fundamental rules and principles that allow the production of restorations that mimic nature. The dental team must imply an organized and systematic approach to diagnose and resolve esthetic problems to create a pleasing smile. There are several methods to evaluate the esthetic fundamentals of a smile; however, some methods are more difficult to quantify than others. The following is a summary of esthetic guidelines that the authors use.

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**Fig 1** Ideal smile line. The patient shows the entire tooth form when smiling. The incisal arrangement and the form of the lower lip should harmonize.



**Fig 2** Correlation of facial symmetry and the dental arch. The maxillary arch should be parallel to the interpupillary line and to the line that runs through the corner of the mouth. The dental midline should be perpendicular to the interpupillary line. These two fundamentals provide the vertical and horizontal symmetry.

## LIP FORM

It is necessary to evaluate the shape of the lips in repose and in function (Fig 1), and the obtained information should be available to all members of the dental team. It is a misconception that the upper lip determines the esthetic value of a case even though the upper lip determines the percentage of tooth structure exposed in a smile. A normal range of incisal tooth exposure would be 30% to 70% in males and 70% to 100% in females.<sup>1</sup> Lip form and size change with age. As a patient ages, the upper lip loses mobility and a smaller amount of tooth structure will be shown. In general, it is the lower lip shape and the incisal edges of the maxillary and mandibular anterior teeth that create a pleasant or unpleasant arrangement. The upper incisal plane and the form of the lower lip in a smile must be harmonious.<sup>2</sup> This guideline is used in the diagnosis, and it is closely related to the arch form and tooth proportion. A very curved lower lip correlates with very dominant central incisors.

## Symmetry

Symmetry is often equivalent to beauty in facial features. Vertical and horizontal symmetry is important, and an applicable guideline is to parallel the incisal plane with a horizontal plane of reference, such as the interpupillary line. This parallelism results in pleasing facial features (Fig 2). Paralleling the midline of the face with the midline of the teeth can achieve vertical symmetry. Symmetry gives a sense of unity and perfection particularly emphasized at the midline. The closer to the midline, the more critical an esthetic guideline becomes (Figs 3 and 4).<sup>3</sup> In this context, symmetry means close similarity but not an identical mirror image. There is no perfect symmetry in nature; such perfection would convey an artificial appearance.





**Fig 3** Dental symmetry: Symmetry gives a sense of perfection emphasized at the midline.



**Fig 4** The midline of the maxillary and mandibular arches does not match. The dental midline and the facial midline do not coincide. Symmetry is in disharmony.



**Fig 5** Ideal axial inclination and zenith. The degree of the axial inclination increases from the central incisors progressively to the lateral incisors and canines.



**Fig 6** Note the lack of harmony in the axial inclination and zenith location.

### *Axial Inclination of the Teeth and Location of the Gingival Zenith*

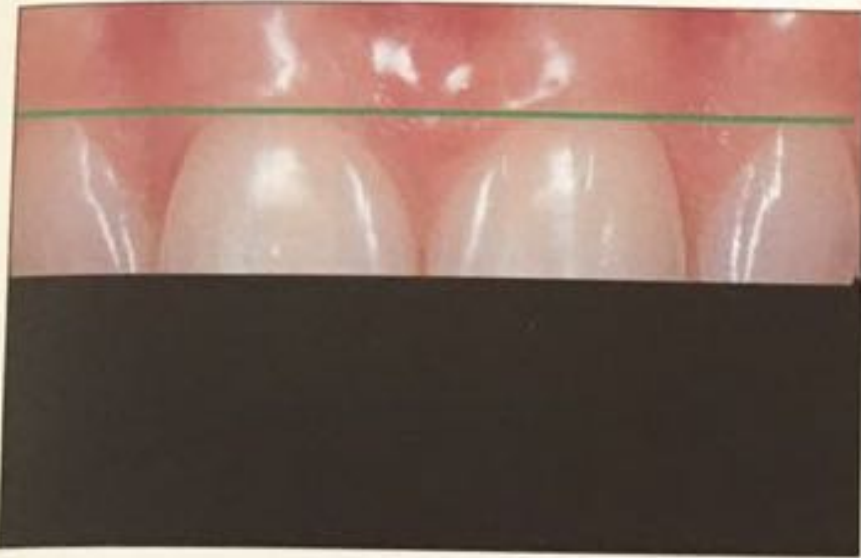
Each tooth has a coronal axis that determines its perceived inclination within the arch. The maxillary anterior teeth should converge toward the midline, and the degree of inclination should increase from the central incisors to the canines. The gingival zenith is the most apical point of the clinical crown of a tooth at the gingival level. Under normal anatomic conditions, this point will be at the junction of the middle and the distal third of the facial aspect of a tooth. The axial inclination and

the gingival zenith will intersect, creating a point of reference. Visual determination will assess the incisal point (Figs 5 and 6).<sup>4-6</sup>

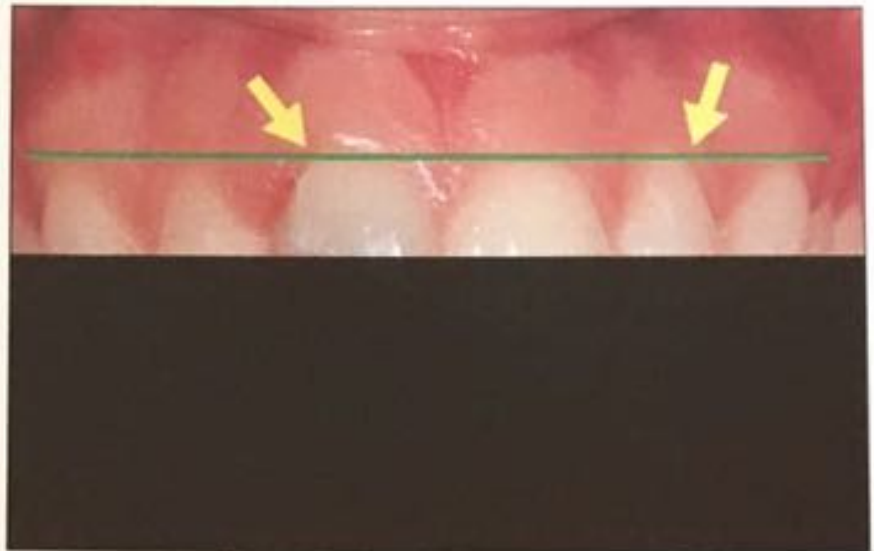
### *Gingival Architecture and Outline*

Gingival architecture and outline relates to the scalloped anatomy displayed by the difference at the gingival level between the midfacial and interproximal areas of a tooth. A normal discrepancy of 5.5 mm is usually pleasing.<sup>7</sup> Tooth proximity, axial inclination, and distance from the bone crest to





**Fig 7** Ideal gingival architecture and outline.



**Fig 8** Discrepancies in the gingival architecture and outline in the area of the maxillary right central and left lateral incisors.

the contact point are some of the factors that will influence the interdental papillae.<sup>8</sup> The dentogingival type (thick flat or thin scalloped) will influence gingival measurements.<sup>9</sup> This guideline also relates to the arrangement of the gingival outlines in the anterior sextant; it dictates that the gingival outline should be symmetric on both sides and should align the gingival architecture of the canines and the central incisors in the same horizontal plane (Figs 7 and 8).<sup>10</sup>

### ***Incisal Arrangement and Embrasures***

The incisal arrangement and incisal embrasures are useful for the evaluation of the esthetics of a patient's smile; however, they commonly change over time due to wear, attrition, and abrasion of the dentition.<sup>11</sup> The incisal edges of the central incisors should be more prominent than those of the lateral incisors. The incisal embrasures define the anatomy of each incisal table. This definition is closely related to the location of the interproximal contact area.<sup>6</sup> The authors believe that the incisal embrasures are related to gender. Females tend to have a more delicate arrangement characterized by deeper and more open incisal embrasures; males tend to have a more dominant display characterized by closer incisal embrasures and squarer incisal anatomy (Fig 9).

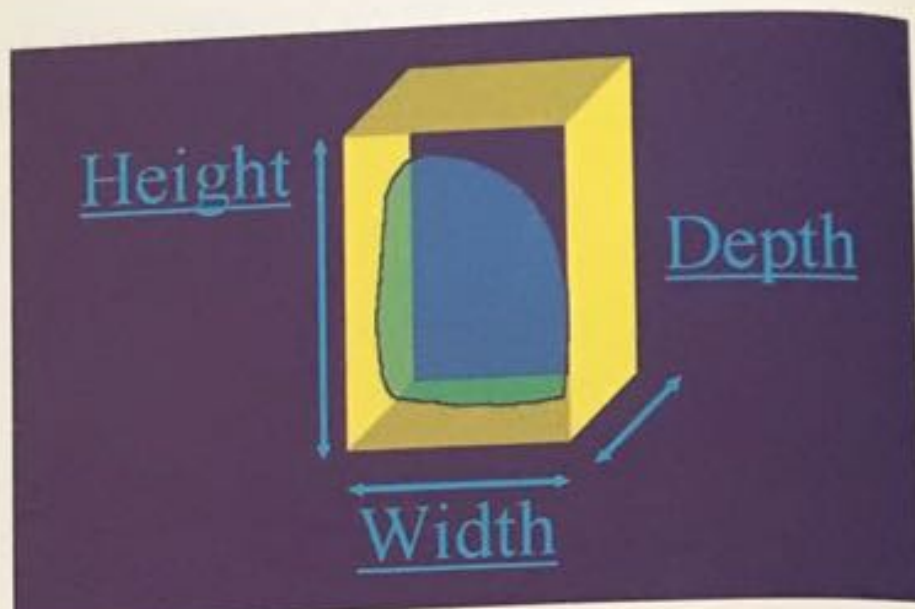
### ***Tooth Proportion***

Tooth proportion is the relation between two measurements derived from dividing the optical width of the tooth by its optical length.<sup>12-15</sup> For better understanding, view the tooth as a geometric body. Therefore, a tooth is a cube and has three dimensions: height, width, and depth (Fig 10). The height and width determine the individual tooth proportion. A pleasant dental proportion for a maxillary central incisor has a range of 0.75 to 0.80. An example of such a proportion is a central incisor that measures 8 mm in width and 10 mm in length. The closer that proportional number is to the unity, the more square the tooth will look. The smaller that number is, the more rectangular and slender the tooth will appear. It is also important to note that the proportion depends on these two variables, width and length, and that a specific proportion can be achieved by increasing or decreasing one of the variables. The dentist must determine which variable has to be modified based on the esthetic principles discussed here. An example of this is peg lateral incisors (Figs 11a and 11b). Changes in any of the dimensions have to be quantified and the direction must be determined. Changes in the width of teeth will affect either the amount of interproximal space, the proportion of the adjacent teeth, or the 3-dimensional location in the arch. Thus,





**Fig 9** Incisal arrangement in a female patient. Note that the central incisors are more prominent, creating a more delicate arrangement for the lateral incisors. Any wear or trauma of the dentition will primarily affect this esthetic principle.



**Fig 10** Tooth proportion: A tooth can be identified as the geometric body of a cube. The existing dimensions of this body are depth, width, and height. The depth relates to the thickness of the tooth or to the tooth preparation if it is modified. The width and height determine the proportion of the tooth.



**Figs 11a and 11b** Dental proportions in a peg lateral case. It is possible to achieve the same dental proportion by increasing the width or by reducing the height; however, shortening the incisal table of the tooth would create a disruption in the incisal arrangement and in the overall frame of reference.

precise measurement during treatment is imperative. Depth dimension determines the buccolingual position of the tooth. The buccal aspect of the tooth extends between the interproximal contacts and gives the tooth its appearance. The lingual contours are directly related to the occlusion and the function. This dimension also configures the relation between the maxillary and mandibular teeth, defining the horizontal and vertical overlap. The final location of the cervical contours and the incisal table should be analyzed, because the

amount of change is going to determine the treatment approach. Prosthetic treatment can modify the final location of the restorations within a range of 2 mm; however, orthodontics will be needed for any correction beyond that. Clinically, the dimension of depth in restorative procedures means the space required for an ideal restoration or for tooth preparation. An adequate tooth preparation allows for sufficient restorative space and for the 3-dimensional changes in the final contours.<sup>16</sup>

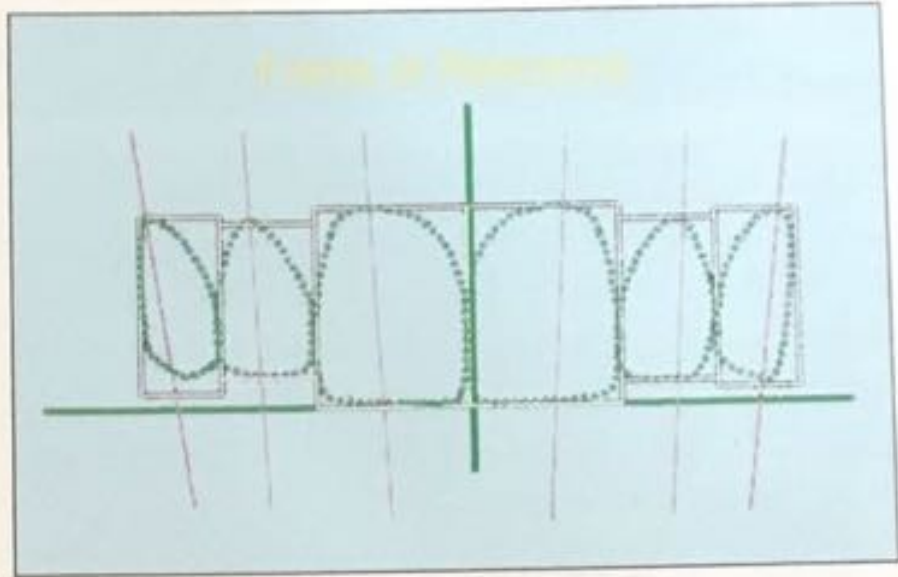


## FRAME OF REFERENCE

### Esthetic principles

- Symmetry
- Axial inclination and gingival zenith
  - Gingival architecture
- Incisal arrangement and embrasures
  - Tooth proportion

**Fig 12** Frame of reference: This esthetic principle combines previously unrelated fundamentals into one.



**Fig 13** Frame of references defined by six contiguous boxes (yellow) that represent the spatial orientation of the anterior sextant. Each portion of the frame is specific to an esthetic principle.

The fundamentals discussed here simplify the analysis of the complex arrangement of anterior teeth.<sup>17,18</sup> They are useful for the understanding of a smile design. However, if aberrations occur, many of these guidelines must accommodate them. The authors propose a new principle, "frame of reference" (Fig 12), which combines all of the aforementioned rules.

## FRAME OF REFERENCE

A frame of reference defines what is to be created. When an artist starts to create a portrait, the first thing he or she does is to draw a series of lines and circles that will form a frame of reference over which the portrait will be drawn. Architects and graphic designers use frames of references and rulers all the time to be able to precisely change the scale without changing the proportions of objects. The frame of reference for the maxillary anterior sextant will consist of six boxes (Fig 13). Each portion of the frame will be specific for an esthetic guideline. The vertical and horizontal lines determine the midline, the symmetry, the gingival outline, and the incisal arrangement. The

boxes will determine the mesiodistal and gingivoincisor space of a tooth, the tooth proportion, and the relation of the proportion of each anterior tooth with each other. When this frame of reference is modified, all the parameters are modified at the same time so that no parameter is overlooked during the process. Every dentate patient has a frame of reference that the teeth and adjacent structures determine.<sup>19</sup> If this frame is deficient and has to be changed, a new frame of reference must be sketched. The frame of reference provides a guideline for the 3-dimensional location of the final restoration and a way to visualize the proposed arrangement and correct mesiodistal and gingivoincisor distribution of the available space. Pythagoras recognized the existence of certain proportions and mathematical relationships, also named the "Golden Proportion." Not every human being's tooth arrangement will follow the same mathematical rules, but it is possible to use existing frames of references seen in pleasant natural dentitions for evaluation and treatment planning. This can be done by computer imaging manipulation and by transferring such information to a diagnostic wax-up.



## CLASSIFICATION OF DIFFERENT CLINICAL SCENARIOS

The frame of reference principle provides a system to diagnose the existing parameters of a smile. Three different scenarios will result: (1) the frame of reference is maintained, (2) the frame of reference is changed without affecting adjacent teeth, or (3) the frame of reference is changed affecting adjacent teeth.

### *Situation 1: Restoration of Teeth Without Changing Their Proportions*

The objective is to restore a tooth or several teeth to their original anatomy, while the existing frame of reference is ideal or adequate for the patient. Young patients with a localized problem will most commonly have this situation. For example, in case 1, the patient had a fractured tooth. The esthetic analysis revealed an ideal frame of reference, and the proposed restoration coincided with the situation. A type I (0.3-mm) tooth preparation and final impression were made, and the technician imitated the characteristics of the natural dentition (Figs 14 to 17).

### *Situation 2: Restoration of Teeth Changing Their Proportions Without Affecting Adjacent Teeth*

The objective is to restore a tooth or several teeth, changing the frame of reference within the tooth envelope. In this situation, the height or width of the tooth will be modified without affecting adjacent teeth. Procedures such as orthodontic movement, gingival surgery, or simple prosthodontic procedures would be some of the means to achieve balance with the rest of the dentition. If interproximal diastemas are present, the modification of the proportions may extend interproximally and/or faciolingually.

In clinical case 2, the patient sought esthetic treatment of her central incisors. The main con-

cern was the discoloration that old composite restorations created (Figs 18a and 18b). The teeth were rotated, and the frame of reference as well as tooth proportions were incorrect (Fig 19). The distal line angles of the central incisors were protruding due to the labioversion, creating a strong distal axis. To plan the new situation, a new frame of reference was computer generated (Fig 20). A type II (0.6-mm) tooth preparation was made, opening the interproximal contact area so that the distal line angle could be relocated to decrease the tooth width. To correct the problem, the width was reduced, which changed the tooth proportion but idealized the axial inclination and the frame of reference (Figs 21 to 24).

### *Situation 3: Restoration of Teeth Changing Their Proportions and Affecting Adjacent Teeth*

This is the most challenging situation. Treatment plan options involving prosthodontics, orthodontics, or surgery should be carefully analyzed. A new assessment of the 3-dimensional space is needed. Changes are accomplished by redistributing the spaces outside the envelope of each tooth. Only treatment of adjacent teeth to accommodate the new frame of reference or an interdisciplinary approach can modify the parameters. Case 3 shows such a clinical situation, where trauma caused a complicated fracture on the maxillary right central incisor (Figs 25a and 25b). Even though the tooth was originally in labioversion, the patient asked that the tooth be restored in an ideal position in the arch. Clinical analysis showed a lack of mesiodistal space to create pleasing tooth proportions. A discrepancy of 25% (Fig 26) in the proportion was found between the space available for the maxillary left and right central incisors. A more favorable frame of reference was computer generated. The amount of space required to redistribute the dental proportions harmoniously was beyond the amount of enamel present in the adjacent teeth. A mathematical equation used to quantify the amount of change

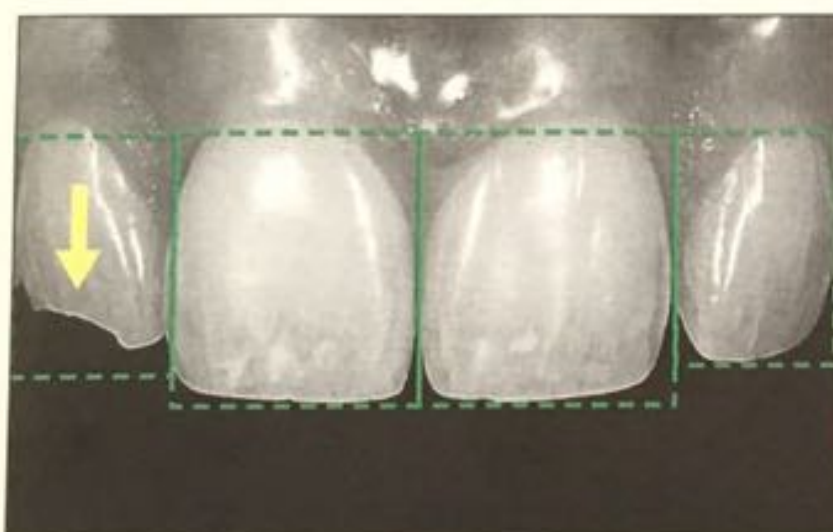


**CASE 1** (Figs 14 to 17)

**Fig 14** Preoperative view. Patient has a harmonious frame of reference except for an incisal fracture on the maxillary right lateral incisor.



**Fig 15** The computer analysis reveals ideal frame of reference. The proposed restoration will coincide with the existing guidelines.



**Fig 16** Summary detailing the treatment goals. The frame of reference acts like a blueprint for treatment execution.



**Fig 17** Postoperative view. A single porcelain laminate restoration was fabricated on the maxillary right lateral incisor.

required demonstrated the need to restore the four maxillary incisors. The new frame of reference created a blueprint for the treatment execution. The first priority was to increase the existing width of the right central incisor in a mesial and distal direction. To achieve that, the width of the left central and both lateral incisors had to be reduced from the mesial aspect. For further control of the proportion, the dimension of height would be decreased gingivally with plastic periodontal surgery. The oblique fragment with subgingival extension was removed, and the biologic width was reestablished. The vertical dimension was fur-

ther decreased by reduction of the incisal length. Such change was carried out throughout all the maxillary incisors to maintain the incisal arrangement (Fig 27). Borrowing space from the adjacent teeth maximized the width of the proposed restoration. Reduction of tooth length further enhanced the proportions. The manipulation of both dimensions reduced the discrepancy and allowed a harmonious prosthetic result. The new frame of reference altered the axial inclination, gingival zenith, gingival contours, and tooth proportion, and it effectively changed the tooth arrangement (Figs 28 to 30).

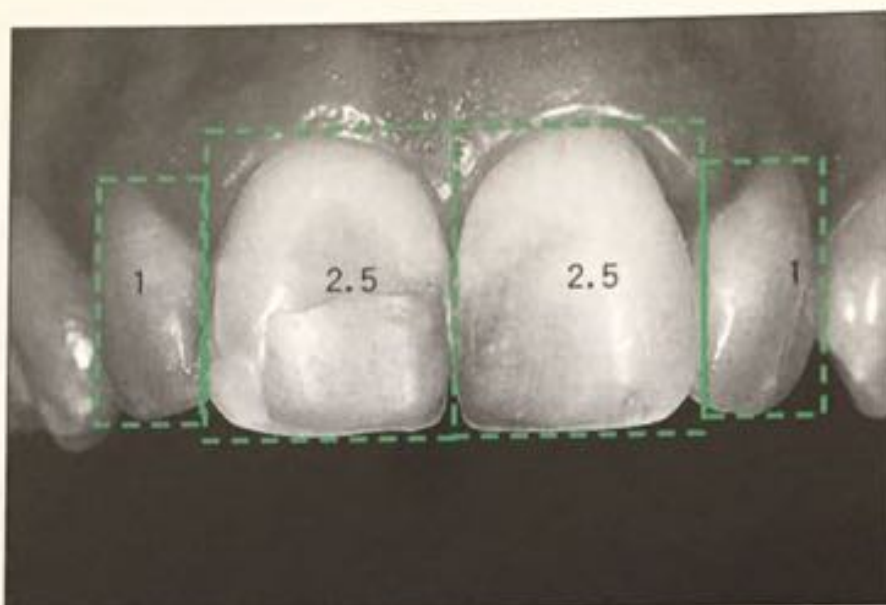


**CASE 2** (Figs 18 to 24)

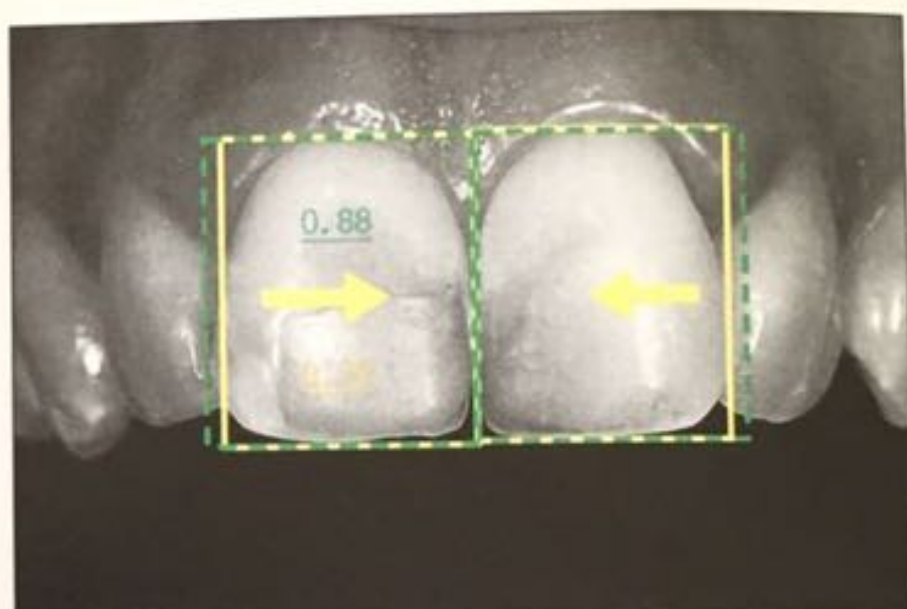
18a



18b



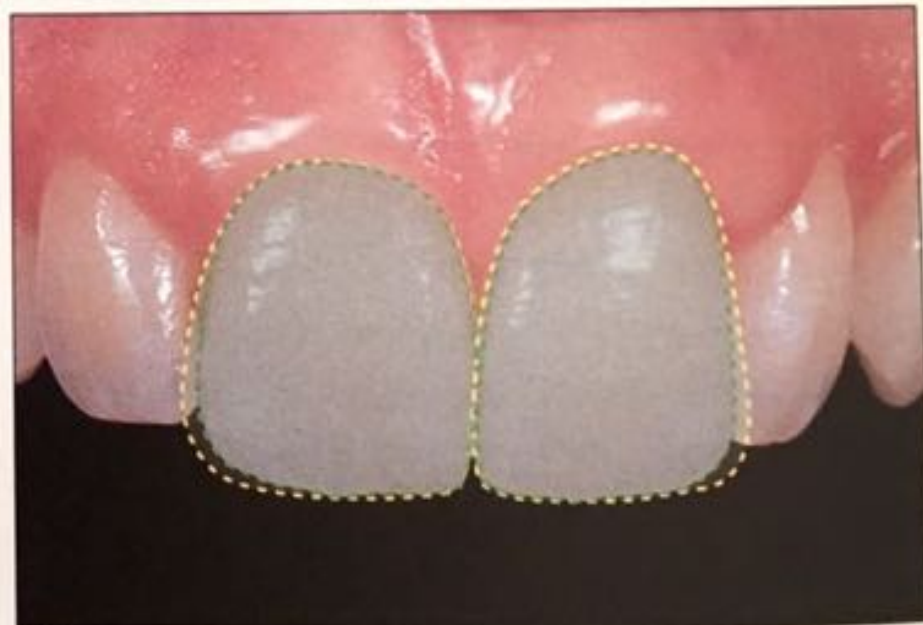
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**Figs 18a and 18b** Preoperative views. The central incisors have stained composite restorations.

**Fig 19** The existing frame of reference. The optical width of the central incisors is incorrect due to the labial rotation of the distal aspect of the teeth. The width of the central incisors should not exceed 1.6 times the dimension of the lateral incisors.

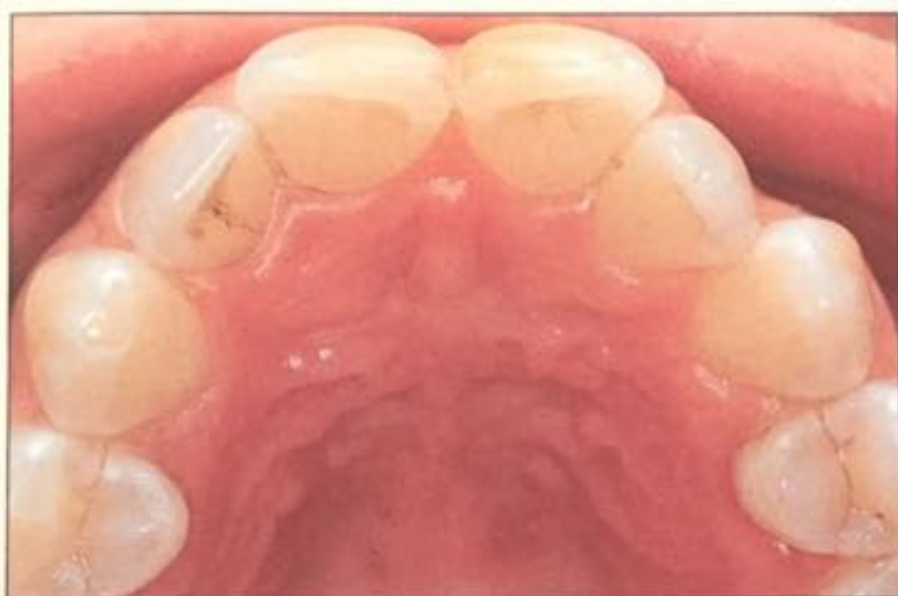




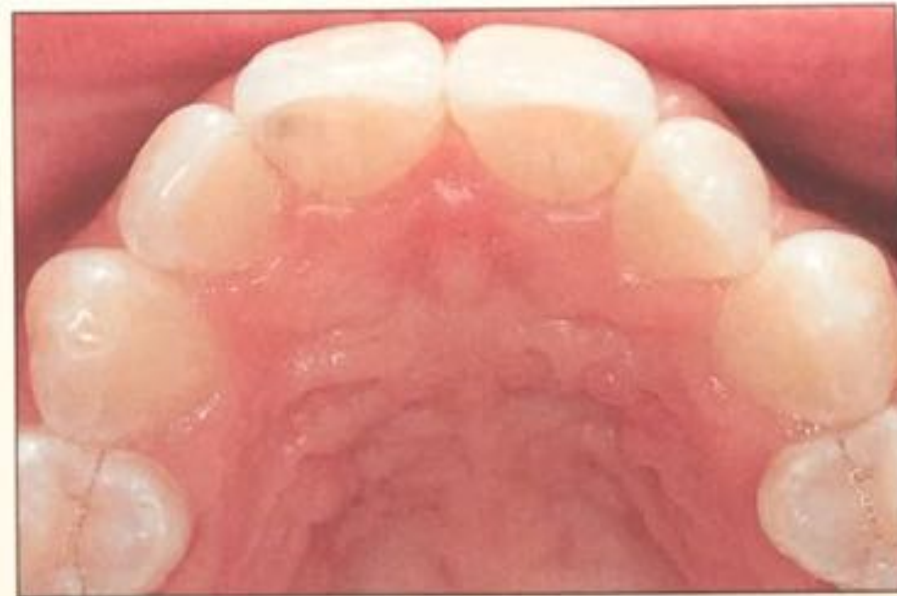
23a



23b



24a



24b

**Fig 20** A computer-generated new frame of reference. The goal is to idealize the tooth proportions. The existing proportions of 0.88 will be decreased to 0.75; at the same time a better optical illusion is achieved in the lateral incisors creating a more harmonious frame of reference. The changes in the anterior arrangement are achieved by modifying the dental proportions without affecting the adjacent teeth.

**Fig 21** New frame of reference over the final restorations. The proportions were idealized by reducing the width from the distal aspect of the central incisors. This procedure kept the midline intact, reduced the distal protrusion, and exposed the lateral incisors, improving the optical arrangement of the entire sextant.

**Fig 22** Superimposition of the preoperative proportions over the final restorations. The length of the central incisors was kept at 10 mm. The width was reduced from 8.8 mm to 7.5 mm. A type II tooth prep-

aration (0.6 mm) was produced based on the final contours. A total tooth reduction of 1.9 mm was done on the distal aspect of the centrals. The space created allowed for the relocation of the interproximal contact area. The net change is 1.3 mm of width reduction on the distal aspect only. The incisal embrasures were rounded to decrease the dominance and to redefine the axial inclination.

**Figs 23a and 23b** Postoperative views of porcelain laminate restorations fabricated on both central incisors.

**Figs 24a and 24b** Preoperative and postoperative incisal views. Note the relocation of the distal and interproximal contact areas and the improvement of the arch form. The dimension of depth (buccolingual) was corrected. Occlusal evaluation in centric relation, lateral, and protrusive excursions was carefully analyzed. The existing envelope of function is respected.

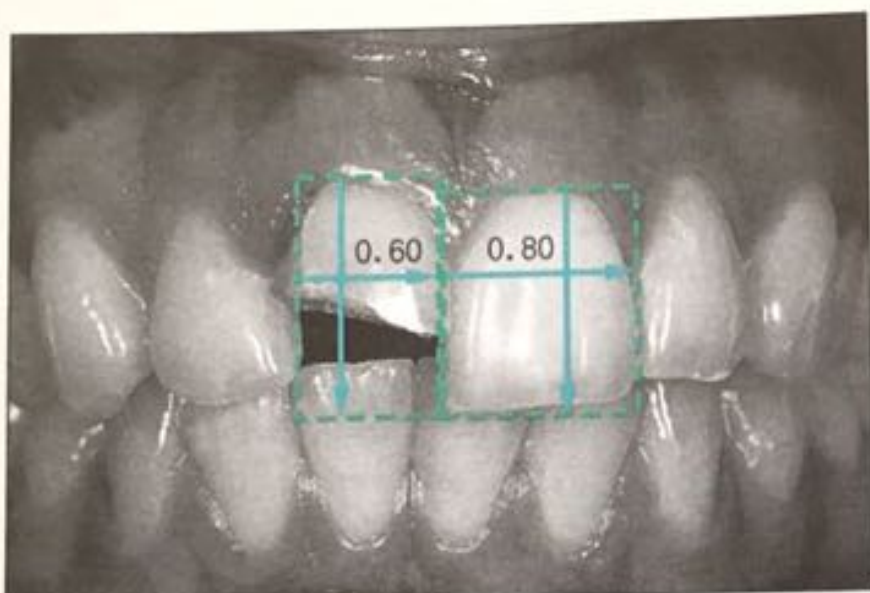


**CASE 3** (Figs 25 to 30)

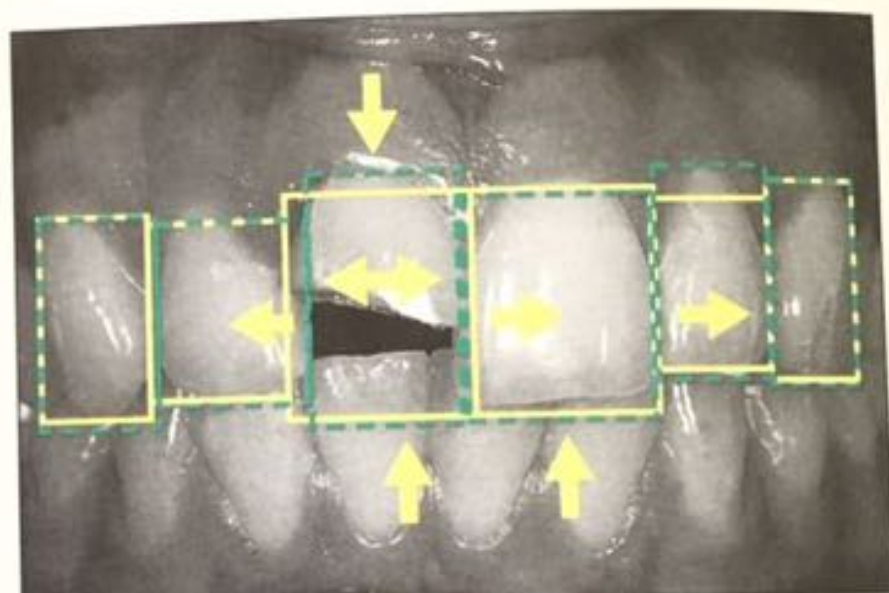
25a



25b



26



27

**Figs 25a and 25b** Preoperative views. Complicated fracture of the maxillary right central incisor with pulp exposure caused by trauma. A secondary oblique fracture extending subgingivally on the distal aspect of the tooth is infringing in the biologic width. Lack of symmetry and harmony of the esthetic fundamentals is obvious and is also shown in Figs 4 and 6.

**Fig 26** Existing frame of reference. Lack of mesiodistal space for the restoration of the maxillary central incisor is evident. The adjacent teeth are invading the original space of the tooth. The existing space is 25% smaller mesiodistally than the dimension of the contralateral incisor. Every esthetic principle is violated.

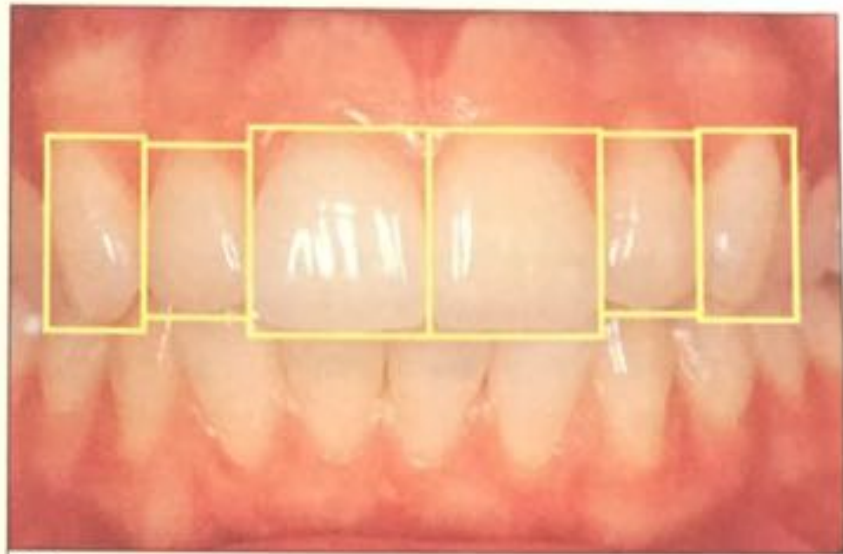
Lack of symmetry, axial inclination, gingival architecture, incisal arrangement, and tooth proportion are off, creating a totally asymmetric plane of reference.

**Fig 27** The proposed frame of reference is computer generated. A mathematical equation used to quantify the amount of change required demonstrated the need to restore the four maxillary incisors. The new frame of reference created a blueprint for treatment execution (shown in yellow). Borrowing space from the adjacent teeth maximized the width of the proposed restoration. Reducing the tooth length further enhanced the dental proportions.





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**Fig 28** Preoperative superimposition on the postoperative view. Note the correction of the esthetic principles.

**Fig 29** Proposed frame of reference over the finished case. Note that most of the changes in proportions were achieved. Correcting the parameters around the midline created harmony and symmetry. The maxillary and mandibular dental midlines are not coincidental; however, a major improvement was achieved. Correction of the mandibular midline requires orthodontic treatment. The slight gingival recession on the maxillary left lateral incisor was not addressed based on the risk/success rate of the procedure.

**Fig 30** Postoperative view. The manipulation of the dimensions of height, width, and depth reduced the discrepancy and allowed a harmonious prosthetic result. This was achieved by root canal treatment on the maxillary right central incisor, placement of a zirconium post and ceramic core, and the fabrication of an all-ceramic crown. Porcelain laminate veneer restorations were fabricated on the other three incisor teeth. Existing occlusal guidelines and envelope of function were carefully respected.



## CONCLUSION

A system of diagnosis and treatment planning facilitates the management of the 3-dimensional problems of the anterior sextant. Computer-aided imaging software and the transfer of the frame of reference can be important tools in patient treatment. Tooth preparation should be designed to accommodate the changes in proportions. Soft tissue health preservation is important, and the biologic width should be respected. If guidelines are changed, soft tissue procedures should accompany such changes. Incisal arrangement should be carefully analyzed in regard to the principles of occlusion. Increasing the incisal length will add more anterior guidance; decreasing the incisal length can be done within the envelope of function. The frame of reference combines previously unrelated principles and therefore offers the clinician a systematic tool to address esthetic issues.

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