

Review Article

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Crowded Teeth Elimination: Proportional and Controlled Narrowing of Upper Incisors

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ABSTRACT

Anterior teeth crowding when the total width of the teeth is greater than the length of the anterior sextant of the dentition, is the most common dento-maxillary anomaly. In order to eliminate crowding of the anterior teeth the reduction of the proximal enamel is widely used to reduce the width of the teeth and improve conditions for subsequent orthodontic treatment [1-6].

Based on the calculation of the anterior sextant of the dentition using the «golden coefficient», it is possible to determine the optimal width of the central and lateral incisors for the anterior sextants of a given length, when all the anterior teeth will be symmetrical and proportional when they are in the correct position [7-10].

For the proportional lack of place distribution for all frontal teeth, it has been proposed to make the enamel reduction of every tooth from both proximal surfaces according to the calculation, with maintaining of contact surfaces and contact point position. Then orthodontic treatment will not require an expansion of the dental arch.

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The “Golden Ratio” Principle

The apparent width of the teeth, as we see it with smile (in the photo there is the projection of the frontal plane) should ideally correspond to the numerical ratio of the “golden section/proportion” and be the Pythagoras’ magic number – 1.618/0.618.

Apparent width of the central incisors should be 1.618 times greater than the visible width of the lateral incisors, respectively the apparent width of the lateral incisors should be 0.618 of the apparent width of the central incisors. This ratio appears ideal, demonstrating the “golden ratio” for artists and photographers depicting a smile from a distance, but not for the dentist who restores teeth in volume and close proximity. The same golden ratios are used in Eddie Levin’s paper templates and digital smile design DSD by Dr. Christian Koachman - all these methods for evaluating and modelling the teeth of anterior sextant are a visual projection onto the frontal plane, in other words, they create a visible picture [11, 12].

The dentist, who is restoring teeth, is like a sculptor, who works on the three-dimensional objects that have a certain arrangement! Just as we observe a sculpture by walking around it from all sides, so dentist restores teeth using all possible visual control directions available.

Furthermore, it turns out that, the real ratio width (mesiodistal tooth size) of incisors’ crowns have a completely different figure and is determined by measuring with oral instrument (with a dental caliper) in volume dimension, and not in a flat image.

Measuring the Frontal Sextants of Dentition

Since the from teeth are arranged in an arch with apparent width ratio of incisor crowns 1.618/0.618, a real width ratio of upper central and lateral incisor is 1.3. An actual ratio of upper central incisor to lower central incisor is 1.3. This coefficient was determined at first by us empirically and was published almost 30 years ago. Right now, at our clinic it is used for each of patient’s dental status assessment as a standard or basic procedure for assessing the norm and identifying deviations from it. The lower teeth, the ratio of the width of the crowns of the lateral and central incisors is 1.1, and the lower lateral incisors are always wider than the central incisors, in contrast to upper ones [7].

Table 1: Standard Sizes of Teeth

Upper dentition	11/21	12/22	13/23	14/24	15/25	16/26	17/27	18/28
Mesiodistal	8,5	6,5	7,5	7,0	7,0	10,5	9,5	8,5
Vestibulo-oral	7,0	6,0	8,0	9,0	9,0	11,0	11,0	10,0
Crown height	10,5	9,0	10,0	8,5	8,5	7,5	7,0	6,5
Lower dentition	41/31	42/32	43/33	44/34	45/35	46/36	47/37	48/38
Mesiodistal	5,0	5,5	7,0	7,0	7,0	11,0	10,5	10,0
Vestibulo-oral	6,0	6,5	7,5	7,5	8,0	10,0	10,0	9,5
Crown height	9,5	9,5	11,0	8,5	8,0	7,5	7,0	7,0

The coefficients are based on the width of the smaller tooth in the anterior sextant, taken as a unit in calculations: in the upper anterior sextant, it is the width of the lateral incisors, in the lower anterior sextant - the width of the central incisors. Later, these coefficients were called "golden coefficients" and it is hard to disagree with that [13].

The Golden Coefficients for the Upper Anterior Sextant are: Central Incisors – 1.3; Lateral incisors - 1; Canines - 1.15; The Golden Coefficients for the Lower Anterior Sextant are: Central Incisors - 1; Lateral Incisors - 1.1; Canines - 1.4.

To assess the norm and the deviations from it, as a reference system, a kind of coordinate system, we use the concept of standard tooth sizes. Regularly determining the width of the frontal teeth crowns with caliper, we assume, based on our practice, that the most of people have exactly the same tooth sizes with an accuracy of 0.1 mm. Of course, this statement needs to be supported by evidence.

The length of the dental arch's frontal section between the canines, on which the four incisors are located, is also accepted by us as a standard and corresponds to 30 mm for the upper sextant and 21 mm for the lower sextant.

Standard Teeth

In case, if the frontal teeth of standard width are located in the frontal area having the standard length, the teeth will then fit into their proper positions, will be having orthognathic position.

If the standard anterior teeth are located in a narrow frontal area, crowding of the teeth cannot be avoided due to a lack of space, and accordingly a wide of space between the teeth forms spaces, and also diastema with be seen when having central incisors with intervening space between them.

Wide Teeth

If the frontal teeth are having larger size and are located on the frontal segment of standard or narrow length then crowding of the teeth will occur. Also crowding may appear with wide frontal section, if there is the shortage of space. It can be also seen as orthognathic position of the anterior teeth, if the sum of anterior teeth width is equal to the anterior sextant.

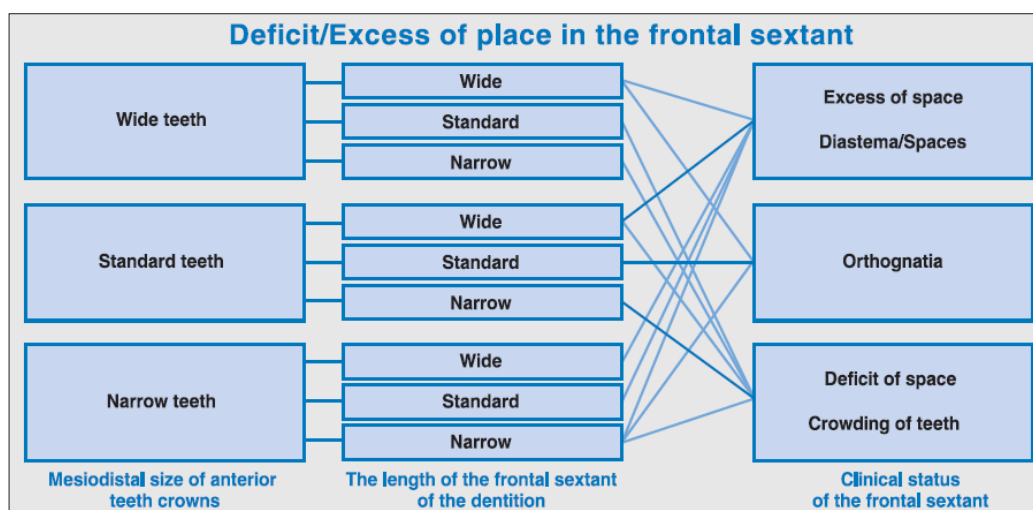
Narrow Teeth

If the frontal teeth width is less than the standard and they are located of the frontal section having a standard length or width, of course, there will be gaps between teeth and a diastema and spaces. Also could be seen correct position of the teeth for a narrow sextant in connection with, the sum of the width of narrow teeth.

Finally, the anterior teeth can be having disproportionate relative to each other, with the lateral incisors showing the greater variability.

To determine the possible cause of crowding, the calculation of the frontal sextant of the dentition, performed with a caliper (a calculator is also needed) on the oral cavity or on the model, as well as digital morphometry on the virtual model (a calculator is not needed) will help.

Table 2: Deficit/Excess of Place in the Frontal Sextant



Proportionally Controlled Enamel Reduction

For treatment of crowded teeth, interproximal enamel reduction method an array of techniques and products are widely used in orthodontic practice. Our idea and experience was to perform the reduction of the proximal enamel in a controlled and proportional ways of treatment based on the calculation of the frontal sextant of the dentition. Proportionally means to distribute the deficit of space to all the frontal teeth according to their specific place in the dentition, maintaining proportion between the canines, central and lateral incisors (golden coefficients) or restoring proportions in case of its violation.

Controlled way of treatment - means the reducing enamel on the both contact surfaces to the same depth, maintaining the shape of the contact surface and the position of the contact points, which is performed under the control by dental measuring caliper. This is the essence of the technique of proportionally controlled narrowing of the crowns of the anterior teeth to eliminate the crowding of the anterior teeth, and it is displayed in the following clinical example. Which comprises of the reduction of the of the proximal incisor enamel according to the calculations of the frontal sextant of the dentition with subsequent orthodontic treatment by using the direct composite restoration technique and restoration of teeth and balance occlusion after restorative treatment [14].

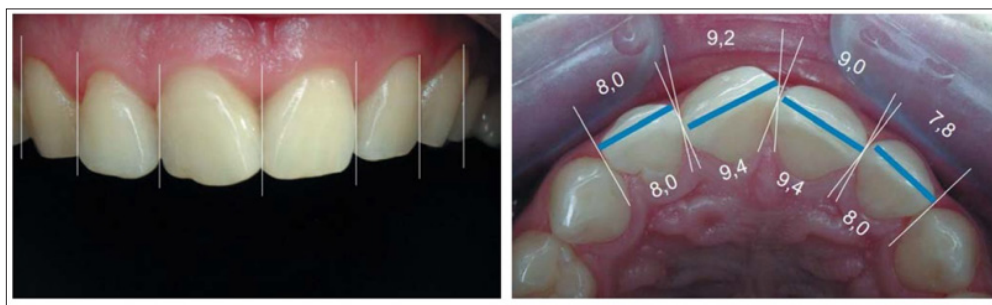


A 28 years old patient has approached us for getting the consultation regarding the crowding of the upper anterior teeth. Since the subject of the article is the restoration of the upper anterior teeth with crowding, we do not provide here the data on the patient's entire dental and general health status. On examination was revealed that the front al sextant of the upper dental arch was of a correct form, on the right side the tooth 12 had vestibular inclination and the tooth 11 was in turn, the canines and incisors had an abrasion of the cutting edges with exposure of the dentin (except for the tooth 12 due to its vestibular inclination).

The size of the incisor crowns attracts our attention: on the image, it was developed that the width of the lateral incisors are almost equal to the width of the canines, thus it becomes clear that the reason of crowding lies precisely in the width of the incisors. However, are all incisors wider or just some teeth? The exact condition of the teeth in the upper front all sextant can be seen by using the dentition calculation method, which is included in the list of mandatory diagnostic procedures for the initial consultation.

The First Stage in calculating the frontal sextant is to measure the transverse dimensions of the crowns of the frontal teeth. Vertical lines fix the visible center of the dentition and visible contacts between the central and lateral incisors, between the lateral incisors and canines, the visible outer contour of the canines. The width of the incisor crowns, measured with a caliper amounted to: lateral incisors - 8.0 mm (standard 6.5 mm), central incisors - 9.4 mm (standard 8.5 mm). Thus, the width of all incisors is greater than the standard, and this is the main reason for the crowding of the teeth in the anterior sextant! [3, 6].

The golden coefficient was 1, 17 (9, 4/8, 0) along with the standard of 1.3. The coefficient of 1.17 in comparison the standard may indicate too wide lateral incisors or too narrow central incisors. The sum of the width of four incisors was $8.0+9.4+9.4+8.0=34.8$ mm.



The Second Stage of the calculations - measurements of dental arch length from canine to canine.

Dental arch from canine to canine presents space for four incisors and were measured by four-dimensional measurements with a dental caliper (corresponding to the number of incisors at a fixed point, which are usually considered as a contact point).

The first measurement from the right canine to medial surface of lateral incisor was 8.0 mm.

The second measurement from medial surface of lateral incisor until medial surface of right central incisor was 9.2 mm.

The third measurement from the medial surface of the right central incisor to the medial surface of the left lateral incisor was 9.0 mm.

The fourth measurement from the medial surface of the left lateral incisor to the contact between the lateral incisor and the left canine was 7.8 mm.

The sum of four measurements was $8.0 + 9.2 + 9.0 + 7.8 = 34$ mm, and this is more than the standard by as much as 4 mm.

Thus, in this clinical case, the crowding of the teeth was due to so wide medial surface that the length of the anterior section, which was 4 mm wider than the standard, was not enough to properly position the four incisors. The space deficit was 0.8 mm ($34 - 34.8$).

The Third Stage of the Calculation is the determination of the width of the lateral incisors for a given length of the dental arch from canine to canine.

To do this, we divide the length of the sextant from canine to canine by the sum of the coefficients of the incisors, having previously determined whether the golden coefficient or another will be used, for example, if the achievement of the ideal proportion is associated with unacceptable damage to the teeth. We always start with the standard value of the golden coefficient - 1.3; the sum of the coefficients of the incisors was $1 + 1.3 + 1.3 + 1 = 4.6$. The optimal width of the lateral incisors was 7.4 mm ($34 \text{ mm} / 4.6$).

The Fourth Stage of the Calculation is to determine the optimal width of the central incisors, for which the resulting width of the lateral incisor should be multiplied by the golden factor. The optimal width of the central incisors was 9.6 mm ($7.4 \text{ mm} \times 1.3$).

The results of the calculation of the frontal sextant must be checked on a calculator ($7.4 + 9.6 + 9.6 + 7.4 = 34$ mm) and with a caliper in the dentition, alas, the contacts between the central and lateral incisors fall on the enamel of the lateral incisors.

It turns out that in order to achieve the “golden” proportion, it is necessary to reduce the lateral incisors by 0.3 mm on each side, and increase the central incisors by 0.1 mm on each side ... Is it possible to reduce enamel damage from narrowing of the lateral incisors and widening of the central incisors.

Yes, it is possible! For this reason, a compromise option was adopted to narrow the incisors with minimal intervention:

- Leave the central incisors unchanged – width 9.4 mm;
- for the lateral incisors, reduce the proximal enamel by 0.2 mm on each side, keeping the shape of the contact surfaces and the position of the contact points – width 7.6 mm;
- the sum of the width of the four incisors will be the desired 34 mm ($7.6 + 9.4 + 9.4 + 7.6$), and the “golden ratio” will increase from 1.17 to 1.23 with an ideal value of 1.30.

Upper Anterior Teeth before Proportional Reduction

Photos of anterior teeth taken at the scale of 2:1 from different positions: from vestibular side and in the dental occlusal mouth mirror along the oral–vestibular axis (right canine/lateral incisor, central incisors, left lateral incisor/canine) at supplemented by the X-ray images taken from the same three positions.

The lateral incisors look disproportionately wide even against the background of wide central incisors, and after calculating the dentition, we know exactly how much the proximal enamel of the lateral incisors needs to be reduced in order to achieve proportionality of the incisors corresponding to the value of the golden proportion.

The aim is to precisely reduce the enamel by exactly 0.2 mm on the lateral and medial surfaces of the lateral incisors, maintaining the shape of the contact surfaces and the position of the contact points, controlling the procedure with caliper and avoiding serious damage to the gingival margins and interdental papillae.

On the vestibular surface of the right canine, a vertical crack is clearly visible, indicating a cyclic functional overload due to bruxism.

X-rays show the incisors root parallelism and the distance between the teeth at the level of the necks, which is greater than usual, due to the thickness of the enamel. This thickness of the enamel allows the planned interproximal controlled reduction of the lateral incisors without the risk of complications.



Upper Anterior Teeth after Proportional Reduction

A proportional controlled reduction of the enamel on the contact surfaces of the lateral incisors was performed under terminal anesthesia with the application of a rubber dam to protect the gingival margin and papillae from damage by abrasive strips.

To reduce the enamel to a thickness of 0.2 mm, it is sufficient to manually operate with steel abrasive strips of coarse and medium grit. Grinding was carried out with metal strips of fine grain size, polishing was carried out with grinding strips, on a Mylar abrasive strip with the ultra-fine grain size. The enamel reduction degree was controlled with a caliper after each stage. After polishing the contact surfaces of the lateral incisors were primed with the adhesive agent Prime & Bond NT, without acid etching to prevent demineralization of the enamel surface during the active period of orthodontic treatment.

On each lateral incisor the enamel was reduced at first on the lateral surface with a reduced increase in the crown by a given 0.2 mm and on the medial surface by a given 0.2 mm. The final width of the lateral incisors was 7.6 mm, which is 0.4 mm less than the initial.

Expected result: after orthodontic incisor rotations, all anterior teeth due to the created spaces should often fill out an anterior sextant of given width, from canine to canine. And if the elimination of crowding of the incisors is carried out without expanding the dental arch, then this reduces the likelihood of recurrence.

Orthodontic Treatment, Active Period

The collaboration of the restorative dentist with the orthodontist determines long-term success in eliminating crowded teeth.

With crowding, the abnormal position of the anterior teeth leads to atypical abrasion of the incisal edges and canine cusps, which becomes visually more noticeable after moving the teeth into an orthognathic position. Therefore, on the one hand, it is so important

to carry out the restoration of displaced teeth to eliminate defects in dental tissues resulting from atypical abrasion, and on the other hand, if crowded anterior teeth are restored before orthodontic displacement, then many anatomical landmarks will be missing for the restoring dentist to model the correct the anatomical shape of an abnormally located tooth.

We are accustomed to restoring the correct anatomical shape of the teeth in the orthogenetic dentition, and if the frontal sextant of the dentition has abnormally located teeth, then the restoring dentist is forced to align the shape of the teeth within the correct dental arch, we call this alignment the reconstruction of teeth and dentition and widely it is used as an alternative to orthodontic treatment [8, 15].

In the rehabilitation of this patient, the reduction of enamel by 0.2 mm of the proximal surfaces of the lateral incisors and the final systemic restoration were performed by us, and orthodontic treatment with the movement of the upper anterior teeth to the correct position in the sextant was performed by orthodontist Lyubov Smaglyuk (Ortex Dental Clinic, Poltava). To complete the reduction of the proximal incisor surfaces, it is important to prime the enamel with a dentinal adhesive agent application technique to prevent enamel sensitivity and caries damage to the contact surfaces during orthodontic treatment [3, 6].

Orthodontic treatment using the straight arch technique lasted 15 months, and as planned, the intact central incisors 9.4 mm wide and the reduced lateral incisors 7.6 mm wide filled the wide anterior sextant of the dentition with a length of 34 mm completely, without spaces and widening of the arch. Sensitivity of teeth and caries of contact surfaces were absent.

The treatment was ended with a direct composite restoration of all teeth and occlusion, followed by the monitoring of the condition of the restored teeth for 13 years.



Restoration of Upper Canines and Incisors

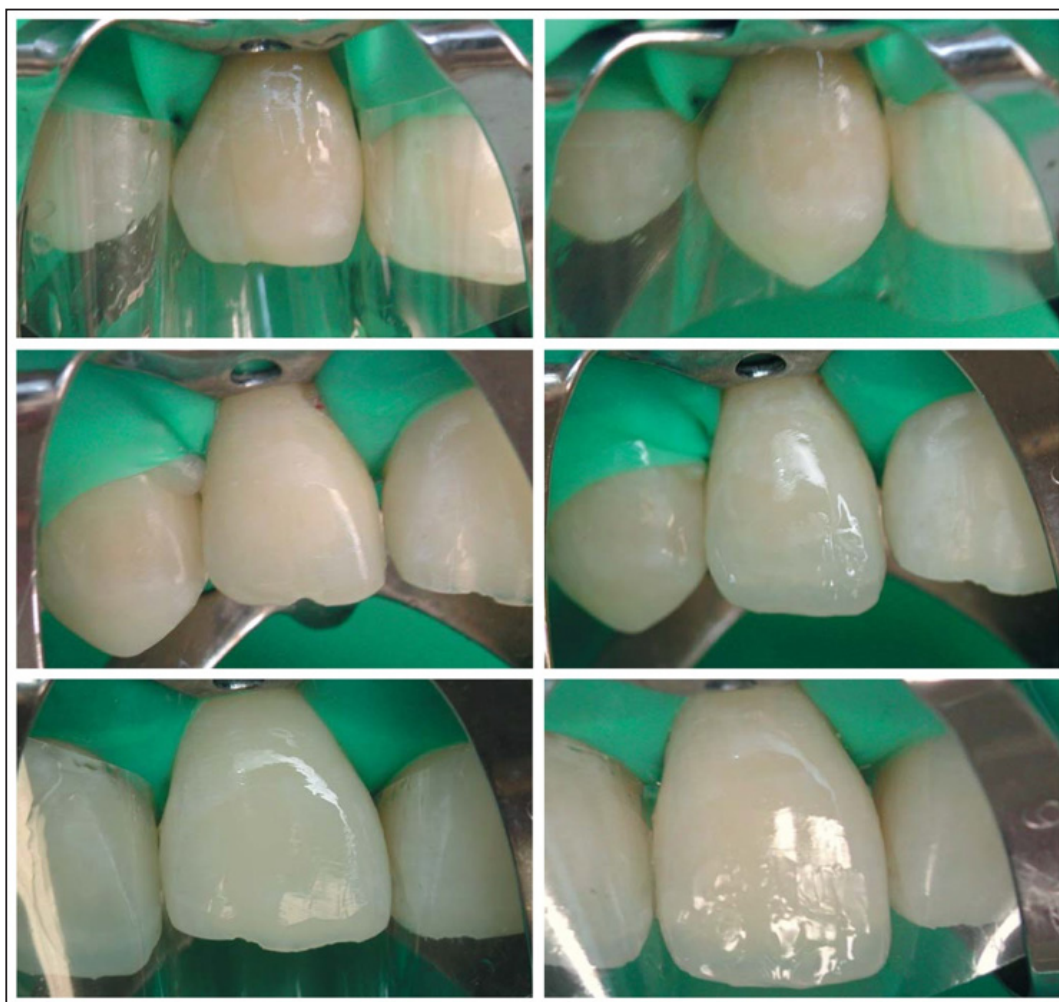
The preparation of dental tissues consisted in removing the surface layer of sclerosed dentin with a spherical diamond bur with a diamond bur having of abrasive particle sizes of 120 microns (disposed dentin on worn surfaces), grinding off exfoliated enamel prisms along the oral edge of the enamel until the optical effect of the “white edge” disappears, forming internal bevels along the edges of the cutting edges, to preserve as much as possible the outer contour and bevel along the vestibular edge of the enamel to provide an “invisible” joint between the enamel surface and the restoration. Enamel preparation was carried out with a finishing diamond bur with abrasive particle sizes of 30 microns (yellow ring).

Restoration of the canine tubercles and incisal edges was carried out using the technique of total etching in accordance with the

topography of the lost dental tissues with three composites: flowable SDR for the hydrophobic coating of the XP-bond adhesive layer, Spectrum TPH micro-hybrid (dentin shade A3.5O) in the dentin topography and nanohybrid Esthet-X (body shade B2 and transparent shade YE) in the enamel topography.

The algorithm of restoration is “from the edges to the center”: first, the canines were restored, then the lateral incisors and central incisors finally, the technique was Free Hand Restoration.

Finishing of the restorations surface was carried out with two finishing burs, starting from the outer surface of the enamel, thus avoiding the coating of the enamel surface with the composite beyond the beveled edges.





Upper Anterior Teeth after Restoration

After grinding and polishing, the upper anterior teeth, restored in a direct free hand technique, have a shiny surface, a symmetrically correct anatomical shape and the ratio of the visible width of the incisors and canines in accordance with the “golden proportion”.

The restored incisal edges and canine tubercles do not have visible joints with the surface of natural enamel; the thickness of the incisal edges is functional and is approximately 1.3 mm, corresponding to the incisal edge of the erupted tooth.

Due to the optical properties of the Esthet-X Nano-hybrid composite and combination of cutting edge of two different colors (body shade and transparent shade) in the topography of the main enamel and superficial enamel, the natural effects of opalescence and halo are reproduced without any tinting, only on account of the perception of visual light with restorative ability.



A 1-Year Follow-Up of the Upper Anterior Restored Teeth

One year after the completion of the active period of orthodontic treatment and the systemic restoration of all teeth and occlusion, the condition of the upper anterior teeth corresponds to the goals of treatment.

Immediately after we adjusted the occlusion after the completion of the restoration of all teeth, a wire retainer was installed by the orthodontist.

The contact points are point-shaped and located along a curve at an equal distance from the cutting edges, the lateral and medial contact surfaces have different curvature in accordance with the anatomical shape, the interdental papillae fill the contact spaces, the gingival margin is normal.

Correctly, shaped anterior sextant, occlusal mirror mounted on the premolars shows an almost perfect ratio of the incisal edges of the incisors and canine cusps.



13-Year Follow-up of Upper Anterior Restored Teeth

During 13 years of follow up observation of restored teeth and occlusion, the patient approached us for some of times with complains about the chips on the lateral incisal edge and canine tubercles, the incisal edges of central incisors were slightly worn (in the occlusal mirror installed on the premolars, it can be seen that the cutting edges are halfway from the plane of the occlusal mirror reflection distance), there was observed a slight rotation of tooth 11, that was considered as a relapse after orthodontic treatment (the retainer was removed after 6 years at the end of the

retention period of orthodontic treatment). An excellent condition of the gingiva was observed.

At the end of the 10-year restorative treatment, a follow up was performed for checking the condition of connection between the restorative and dental tissues (detection of debonding) and the renovation of the posterior teeth (replenishment of the worn- up restorations) was done and since then the condition of the upper anterior teeth inspires a cautious optimism.

Resume

The presented clinical case of reduction based on the calculation of the proximal enamel of the upper incisors, followed by orthodontic normalization of the position of the teeth in the anterior sextant and the restoration of tooth crowns in direct restoration having a 13-year long result, showed one of the possibilities for using the author's calculation of the dentition and the system for assessing standard tooth sizes.

The calculation of the frontal sextant by the "golden coefficients" allows:

- determine the symmetry and proportionality of the front teeth.
- determine the symmetry and proportionality of the dentition.
- compare the length of the frontal sextant with the width of the front teeth, determining the deficit / excess of space in the sextant.
- identify possible causes of violation of the symmetry and proportionality of the teeth and dentition.

- determine the optimal mesiodistal dimensions of the crowns of the anterior teeth for a given frontal sextant.
- eliminate in a controlled and predictable manner violations of the symmetry and proportionality of the teeth and dentition.

Due to the calculation of the dentition, it was revealed that the crowding of the upper teeth of this patient refers to a combination of a wide anterior sextant and wide teeth and that the lateral incisors, whose width of 8 mm exceeded by 0.6 mm the calculated optimal width according to the "golden coefficient" of 1.3 for a sextant 34 mm long.

To normalize the position of the incisors in the dentition without expanding the dental arch, a proportional controlled reduction of the proximal enamel of the lateral incisors was used in a compromise version of minimal intervention: the initial width of the central incisors was taken as the basis, and then, to fill the space from canine to canine, the optimal width of the lateral incisors was 7.6 mm.

Proportional controlled reduction of the lateral incisors was performed by 0.2 mm from each proximal surface by using the metal abrasive strips, maintaining the shape of the contact surfaces and the positions of the contact points, followed by priming the enamel with a dentin adhesive agent.

Orthodontic treatment in the active and retention period, elimination of defects in cutting edges with composite in direct free technique, revealed a successful clinical result with follow-up for 13 years after systemic restoration.

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