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Tetragon: A Visual Cephalometric Analysis

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This article is intended to provide the student, the clinician, and the researcher with a simple, logical, and accurate visual cephalometric analysis. The analysis is based on two geometric constructs:

1. The "Tetragon", a polygon that represents the maxillo-dento-mandibular complex, made up of reliable and familiar cephalometric landmarks – the palatal plane, the mandibular plane, and the axes of the maxillary and mandibular central incisors (Fig. 1).

2. The "Trigon", a complementary triangle situated above the Tetragon and formed by one plane that is intrinsic to the Tetragon – the palatal plane (PNS-ANS) – and two that are extrinsic – the pterygo-orbital plane (Pt-Or) and the pterygopalatal plane (Pt-PNS).

Construction of the Tetragon

The Tetragon has four sides, forming four angles that always add up to 360°. In an "ideal" skeletal and dental Class I patient, the four angles are as follows (Fig. 2):

1. Intersection of the palatal plane and the axis of the maxillary central incisor (110°).

2. Intersection of the maxillary and mandibular central incisor planes (130°).

3. Intersection of the mandibular incisor axis and the mandibular plane (90°).

4. Intersection of the mandibular plane and the palatal plane (30°).

For better visualization, the incisal edges are indicated by arrows (Fig. 3).

If any angle is modified, either by growth or by orthodontic treatment, the angles of the Tetragon will change, but their sum will still be 360°. If that is not the case, it means either that the tracing is inaccurate or that one or more angles have been calculated incorrectly.

An apparatus called a Tetragoniometer, constructed from four protractors and four sliding rulers, can be used to measure the Tetragon and to show how the various planes and angles will change when any one is modified (Fig. 4). I developed this device from the Craniofacial Pantograph of Morales,1 which is based on Jarabak's Polygon.

Construction of the Trigon

In an ideal skeletal and dental Class I occlusion (Fig. 2), the angles of the Trigon are as follows:

1. Intersection of the Pt-Or plane and the Pt-PNS plane, called "Upper Pt" (85°).

2. Intersection of the Pt-PNS plane and the palatal plane, called "Lower Pt" (87°).

3. Intersection of the Pt-Or plane and the palatal plane (8°).

In any patient, the three angles should always total 180°. If the Trigon points anteriorly (toward the face), it is positive, indicating that the Tetragon is inclined upward or counterclockwise (Fig. 5). If it points posteriorly, it is negative, indicating that the Tetragon is inclined anteriorly, away from the palatal plane, in a clockwise direction. If the palatal plane and the Pt-Or plane are parallel, their angulation will be neutral or 0°, but the sum of the two remaining angles will still be 180°.

Patient Sample

The planes and angles of the Tetragon and Trigon are expressed in round numbers, with a standard deviation of ±3°, representing an ideal Caucasian skeletal and dental Class I patient. The values are based on an average of Caucasian and native Mexican individuals, whose cephalograms were obtained from the following sources:

1. My private practice.

2. The Graduate Orthodontic Department of the Universidad Intercontinental (UIC) in Mexico City.

3. The Universidad Autonoma de Tamaulipas (UAT) in Tampico, Mexico.

4. The Universidad Popular Autonoma del Estado de Puebla (UPAEP) in Puebla, Mexico.

5. A study by Doddoli of teen-age Purepecha Indians in the Mexican state of Michoacan.2

6. The master's thesis of Gonzalez,3 which used the Tetragon as a cephalometric analysis.

Data of other respected authors are presented for comparison.

The values obtained from my practice differ slightly from the other Mexican samples because my patients are mainly Caucasians of European origin. The three graduate orthodontic departments and the pure Indian study exhibit a typical Mexican tendency toward bimaxillary protrusion (Tables 1 and 2).

Overall, there are only minor differences in the elements of the Tetragon among these samples, indicating that the average values are valid for different ethnic populations. It should be remembered, however, that these values are not absolute. Every clinician should carefully determine his or her own preferred values for use in the Tetragon and Trigon.

Discussion

Together, the Tetragon and the Trigon provide a clear picture of the position of the maxillo-dento-mandibular structures within the craniofacial complex. This visual cephalometric analysis can be a useful diagnostic tool for treatment planning, surgical preparation, and evaluation of growth, treatment progress, and post-treatment results.

The Pt-Or plane is a useful reference because of its stability and its proximity to the structures involved in orthodontic treatment. For accurate superimpositions, therefore, the Tetragon should be oriented on the Pt-Or plane and registered on Pt. The pterygomaxillary fossa, which has an upper limit of Pt point and a lower limit of the curved junction with the posterior nasal spine, is formed by osseous structures that house many important nerves and blood vessels. It seems to remain stable

throughout the life of an individual, as recognized by Enlow.8 The angle formed by the intersection of the Pt-Or plane, which represents the cranial base, and the palatal plane, which represents the base of the maxilla, indicates the overall inclination of the Tetragon.

One of the most significant components of the Tetragon is the relationship of the palatal plane to the long axis of the maxillary central incisor–the upper incisor palatal plane angle (UIPPA). This angle has been neglected or ignored in most cephalometric analyses, but is just as important as the lower incisor mandibular plane angle (LIMPA).

When the maxilla, represented by the palatal plane (ANS-PNS), is relocated, the angulation of the maxillary incisor should be in harmony with the palatal plane, just as the mandibular incisor is placed in relation to the mandibular plane. The inclination of the palatal plane is especially important in cases of open bite, deep overbite, severe overjet, hypoplasia, or prognathism. The Tetragon can assist the orthodontist and the oral surgeon in deciding when impaction, retraction, or projection of the maxilla should be contemplated.

The Tetragon, in conjunction with traditional cephalometric measurements such as SNA, SNB, ANB, and NPg, can also indicate whether the problem with the malocclusion lies in the mandible or the maxilla or both. Because the anterior planes of the Tetragon represent the axial inclinations of the maxillary and mandibular central incisors and their positions in space, the analysis will indicate whether they need to be intruded, extruded, or retracted.

Case 1

A 13-year-old female presented with a Class II, division 1 malocclusion, a slightly concave profile, and crowding in both arches (Fig. 6). The initial visual cephalometric analysis (Table 3) indicated that the maxillary incisors were protrusive relative to the palatal plane (123°), while the mandibular incisors were retrusive relative to the mandibular plane (80°). The severe overjet was confirmed by the anteroposterior relationship (NPg-UI of 11mm compared to NPg-LI of 1mm). Both SNA and SNB were slightly retrusive, with an ANB differential of 2°.

Because of the patient's age and tooth-size discrepancy, two maxillary first bicuspids and the mandibular right central incisor were extracted to achieve a functional Class II molar and Class I canine relationship, and to eliminate the overjet and crowding.

After 25 months of treatment, the patient had a harmonious musculature (Fig. 7). Her profile was attractive, although still slightly concave; the midlines were not coincident due to the mandibular incisor extraction. Final cephalometric analysis showed that UI- PP was reduced considerably, to 103°, with an intrusion of 1mm. The interincisal angle was increased by 4° due to the retraction of the maxillary incisors and the uprighting and proclination of the mandibular incisors.

Case 2

In this Class III case with maxillary hypoplasia and mandibular prognathism, orthodontic treatment was combined with orthognathic surgery. Figure 8 shows the visual cephalometric analysis, SNA, SNB, and ANB before treatment, after the presurgical orthodontic treatment, and after surgery.

The esthetic plane clearly indicates the straightening of the soft-tissue profile produced by a combination of forward positioning of the maxilla and backward positioning of the mandible. The palatal plane was inclined during the presurgical orthodontics, but recovered its position after

surgery. In this case, the NPg plane coincided with the NB plane. The NA and NB planes were inverted in the first and second stages, but after surgery showed a normal relationship, indicating a balanced occlusion and facial harmony.

Conclusion

The clinician should keep in mind that the Tetragon and Trigon represent only two dimensions, and that every patient is tridimensional, with unique individual characteristics. Nevertheless, the visual cephalometric analysis shown here can be a valuable diagnostic tool, thanks to its simplicity and accuracy in tracing, measurement, superimposition, and reproduction. □

FIGURES

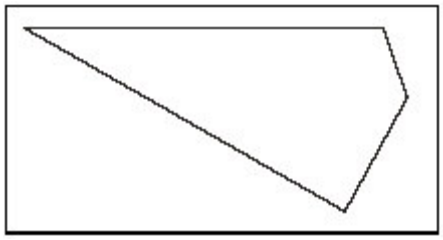

Fig. 1 Tetragon represents maxillo-dento-mandibular complex.

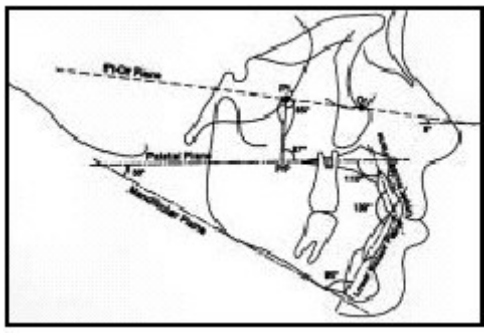

Fig. 2 Planes and angles of Tetragon and Trigon in "ideal" skeletal and dental Class I patient.

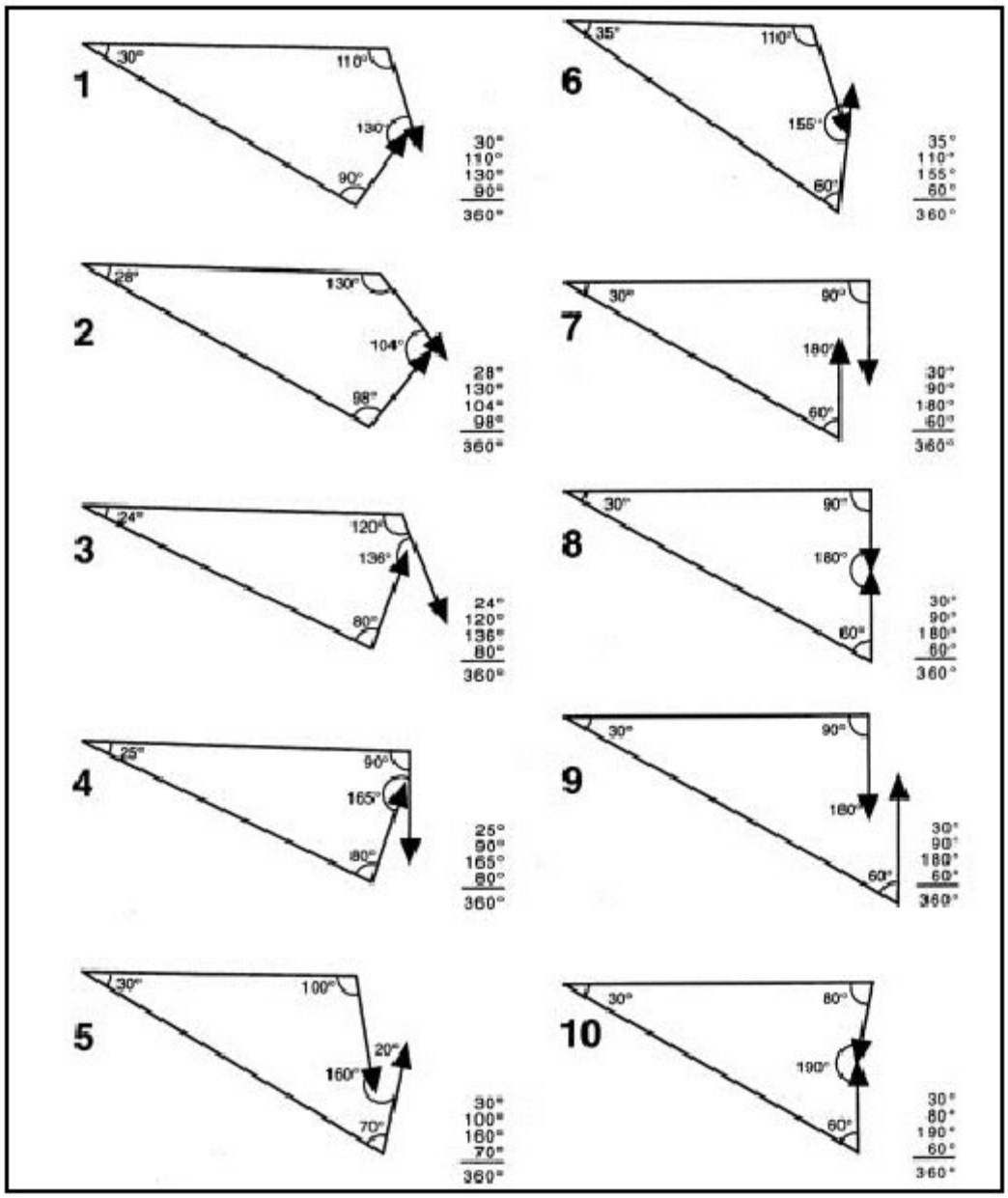

Fig. 3 Various configurations of Tetragon. 1. Typical Class I malocclusion. 2. Class I malocclusion with double protrusion. 3. Class II, division 1 malocclusion. 4. Class II, division 2 malocclusion. 5. Class III malocclusion with retrusive maxillary incisors and large mandible. 6. Class III malocclusion with slightly retrusive maxilla, large mandible, and lingually inclined mandibular incisors. 7-9. Cases with parallel incisor planes. 10. Case with lingually inclined maxillary and mandibular incisors.

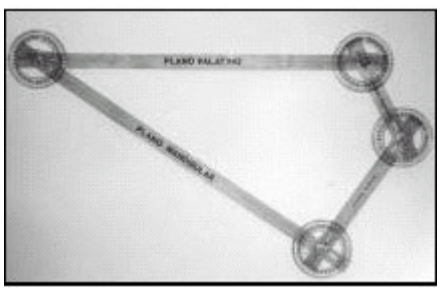

Fig. 4 Tetragoniometer for measuring Tetragon and indicating effects of changes in any planes or angles.

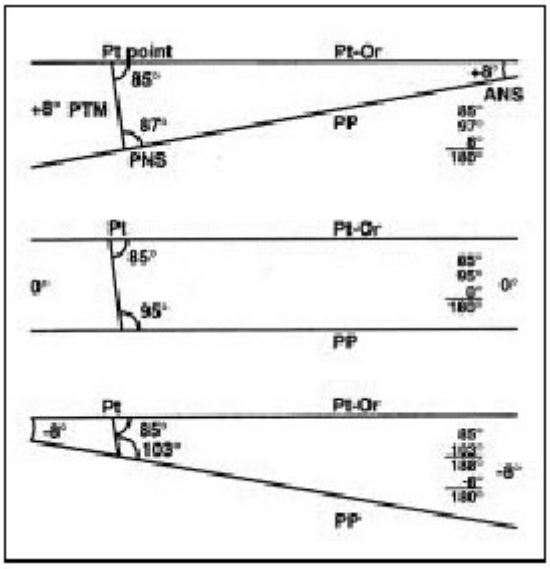

Fig. 5 Trigon indicates inclination of Tetragon.

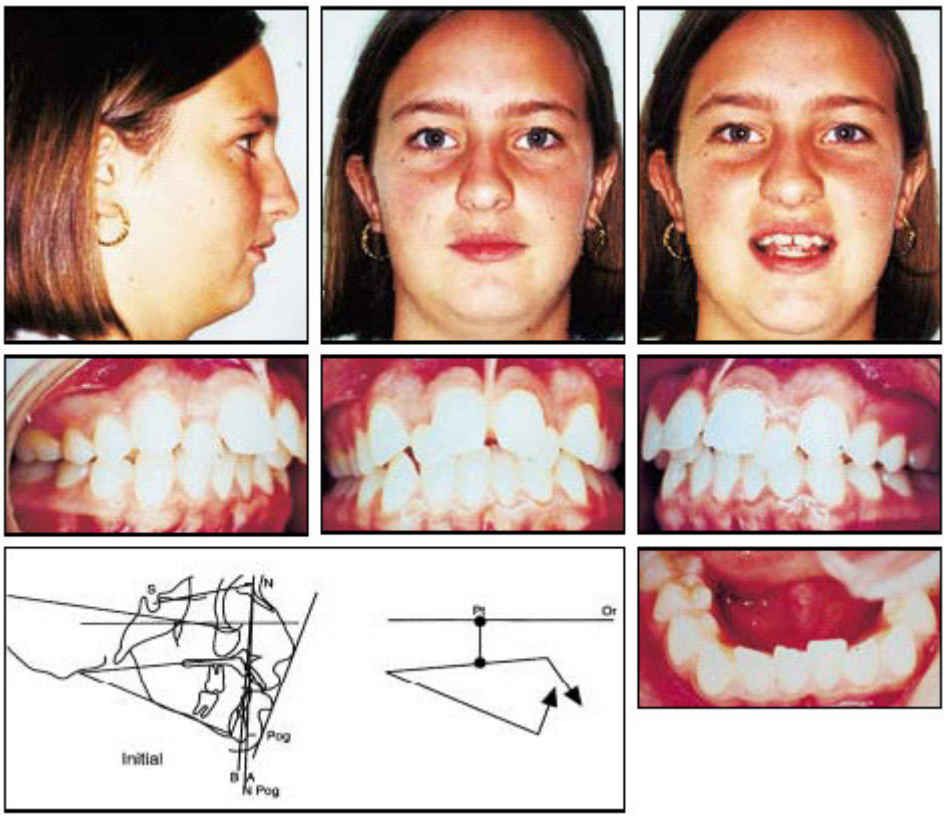

Fig. 6 Case 1. 13-year-old female with Class II, division 1 malocclusion and crowding before treatment. Tetragon and Trigon are represented schematically.

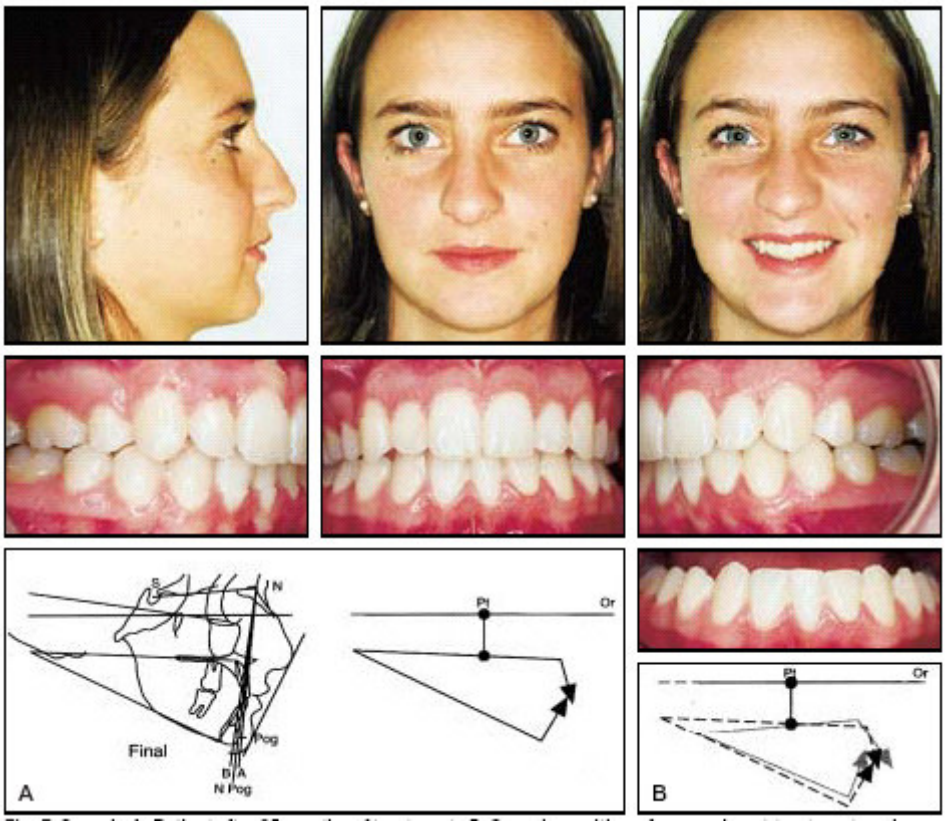

Fig. 7 Case 1. A. Patient after 25 months of treatment. B. Superimposition of pre- and post-treatment analyses.

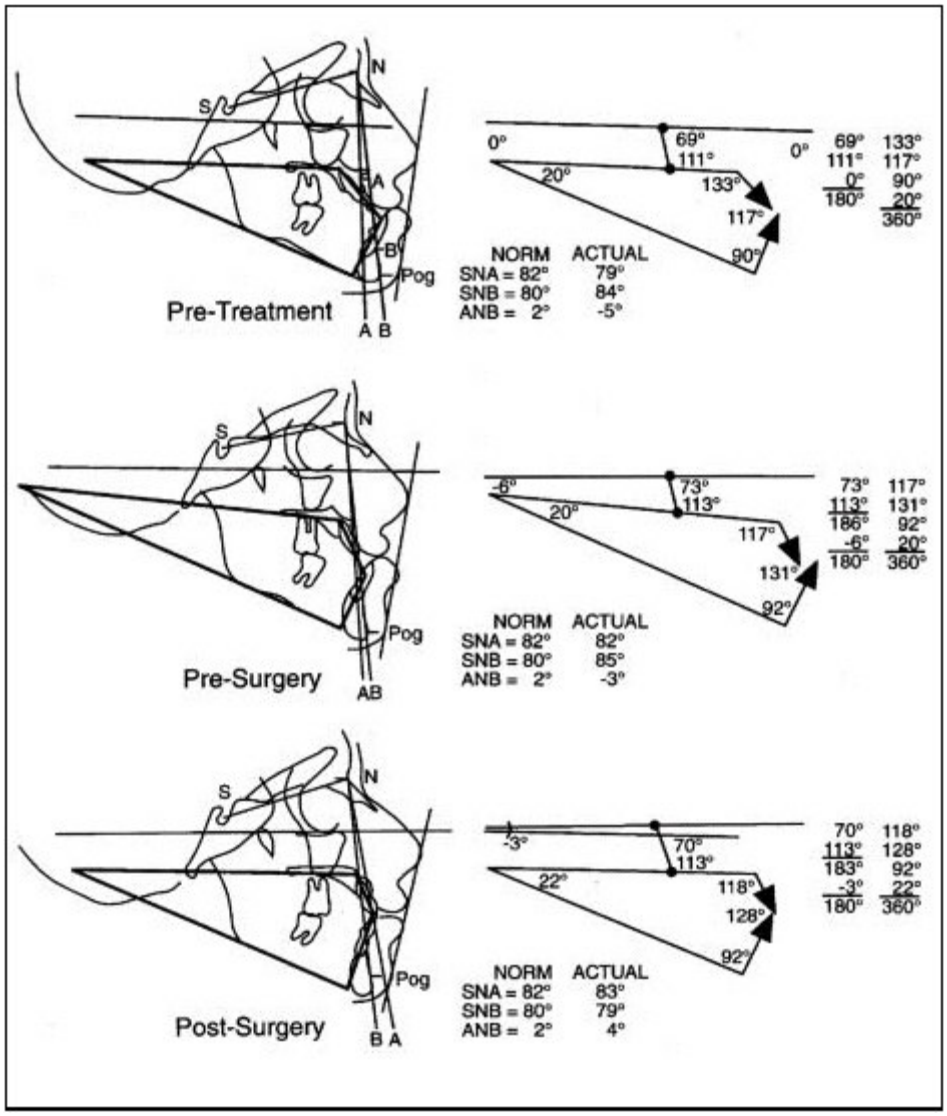

Fig. 8 Case 2. Class III surgical-orthodontic patient with maxillary hypoplasia and mandibular prognathism.

TABLES

TABLE 1
AVERAGE VALUES OF TETRAGON ANGLES

	UI-PP	UI-LI	LI-MP	MP-PP	Total
Fastlicht	110°	130°	90°	30°	360°
Doddoli[2]	114°	121°	96°	29°	360°
Gonzalez[3]	115°	122°	93°	30°	360°
UIC	114°	126°	93°	27°	360°
UAT	118°	117°	97°	28°	360°
UPAEP	114°	122°	96°	28°	360°
Broadbent[4]	108°	140°	91°	21°	360°
Graber[5]	110°	135°	90°	25°	360°
Riolo[6]	112°	127°	95°	26°	360°
Schwarz[7]	110°	140°	90°	20°	360°
Average	113°	128°	93°	26°	360°

Table. 1

TABLE 2
AVERAGE VALUES OF TRIGON ANGLES

	Pt-Or/Pt-PNS	Pt-PNS/PP	Pt-Or/PP	Total
Fastlicht	85°	87°	8°	180°
UIC	77°	92°	11°	180°
UAT	81°	91°	8°	180°
UPAEP	82°	89°	9°	180°
Average	81°	90°	9°	180°

Table. 2

TABLE 3
CASE 1: VISUAL CEPHALOMETRIC ANALYSIS

	Norm	Initial	Final
Age		13.9	15.10
Tetragon			
UI-PP	113°	123°	103°
UI-LI	128°	127°	131°
LI-MP	93°	80°	96°
MP-PP	26°	30°	30°
Sum of Tetragon Angles	360°	360°	360°
Trigon			
Pt-Or/Pt-PNS	81°	77°	73°
Pt-PNS/PP	90°	89°	88°
Pt-Or/PP	9°	14°	19°
Sum of Trigon Angles	180°	180°	180°
Linear Measurements			
NPg-UI	+2-4mm	+11mm	+3mm
NPg-LI	–2-+2mm	+1mm	+1mm
UI-PP	34mm	29mm	28mm
LI-MP	43mm	39mm	39mm
Angular Measurements			
SNA	82°	78°	77°
SNB	80°	76°	74°
ANB	2°	2°	3°

Table. 3

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