Cephalometric VTO : A Blueprint

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Abstract

A Visual Treatment Objective (VTO) is like a blueprint or a visual plan to forecast the normal growth of the patient and the anticipated influences of treatment, to establish the individual objectives we want to achieve for that patient. Treatment for a growing patient must be planned according to growth changes, not according to the skeletal structure that the patient presents initially. The treatment plan should take advantage of the beneficial aspects of growth and minimize any undesirable effects of growth, if possible. After setting up the teeth ideally within the anticipated or "grown" facial pattern, the orthodontist must decide how far he must go with mechanics and orthopedics to achieve his goals, whether it is possible to achieve them, and what the alternatives are. In this article we would disscussing four different methods of cephalometrics.

Keywords: Growth, VTO, Orthodontics, Prediction, Cephalometrics.

Introduction

Orthodontic treatment is monitored with progress head films, usually at 6-month intervals. Whenever a case is encountered in which growth is occurring in a different direction than expected, a new midtreatment VTO is then constructed so that changes in treatment procedures can be made and any disfiguring lip responses can be avoided.[2] Whenever possible, it is a good plan to take head films for a year or two prior to beginning treatment and thus develop a growth profile for the case, assuming that there is an opportunity to examine the patient that early. Developing pretreatment growth profiles of our patients helps to overcome our inadequacies in growth forecasting.[1]The visualized treatment objective is a simple yet relatively accurate method of predicting the incisor and molar relations on the basis of growth and treatment alterations of the dentoskeletal framework. Obtainable treatment objectives are recorded on the original acetate tracing. In addition to space calculations, direction and magnitude of tooth movement are clearly indicated. Not only is the visualized treatment objective an excellent visual aid during case presentation, it may also be used to check on possible "midcourse" corrections during treatment and the evaluation of the final result compared with the original prediction.[2-4]Orthodontists have recognized the potential of computer graphics in the research and diagnosis of dentofacial disorders. Recent advances in microcomputer technology have led to innovations that are making graphics programs available and affordable for dental professionals.[4-7] Their detailed findings about the malocclusion can be overwhelming to a patient who is primarily interested in esthetics. An orthodontist armed even with the most meticulous tracing and VTO will rarely find a patient who can thoroughly understand final treatment goals from a two-dimensional cephalometric tracing and plaster models.[7-8]

1. Rickett's Method[1,9]

Construct a VTO in the following sequence:

(a) The cranial base prediction,
(b) The mandibular growth prediction,
(c) The maxillary growth prediction
(d) The occlusal plane position,
(e) The location of the dentition,
(f) The soft tissue of the face

(I) VTO-Cranial Base Prediction: Place the tracing paper over the original tracing and starting at CC point, follow these steps to construct the cranial base. Trace the Basion-Nasion Plane. Put a mark at point CC. Grow Nasion 1mm/year (average normal growth) for 2 years (estimated treatment time).. Grow Basion 1mm/year (average normal growth) for 2 years (estimated treatment time).Slide tracing back so Nasions coincide and trace Nasion area.. Slide tracing forward so Basions coincide and trace Basion area. (Fig. 1)

(II) VTO-Mandibular Growth Prediction Rotation : The construction of the mandible and its new position start with the rotation of the mandible. The mandible rotates open or closed from the effects of the mechanics used and the facial pattern present. The average such effect on mandibular rotation is as follows: Mechanics: Convexity Reduction Facial Axis opens 1°/5mm,,Molar Correction Facial Axis opens 1°/3mm, Overbite Correction Facial Axis opens 1°/4mm,Crossbite Correction Facial Axis opens 1°-1½°. Recovers half the distance, Facial Pattern Facial Axis opens 1°/1 S.D. dolichofacial; 1° closing effect against mechanics if brachyfacial. In constructing the VTO, these factors must be taken into consideration in deciding what can be expected to happen to the facial axis. Treatment may open the facial axis as with Class II mechanics, or it may close the facial axis as with the use of high pull headgear or due to extraction. Facial axis opens 1° for 5mm of convexity reduction, for 3mm of molar correction, and for 4mm of overbite correction. It opens 1° to 1½° in crossbite correction and recovers half that amount. For every standard deviation on the dolichofacial pattern side, it opens 1° and for every standard deviation toward the brachyfacial side, it tends to close one degree. Superimpose at Basion along the Basion-Nasion plane. Rotate 'up' at Nasion to open the bite and 'down' at Nasion to close the bite using point DC as the fulcrum. This rotation depends on anticipated treatment effects (whether treatment can be expected to open or close the facial axis). Trace Condylar Axis, Coronoid Process, and Condyle. (Fig 2)

(III) VTO-Mandibular Growth Prediction Condylar Axis Growth & Corpus Axis Growth: On condylar axis, make mark 1mm per year down from point DC. Slide mark up to the Basion-Nasion plane along the condylar axis. Extend the condylar axis to XI point, locating a new XI point. With old and new XI points coinciding, trace corpus axis, extending it 2mm per year forward of old PM point. (PM moves forward 2mm/year in normal growth.)Draw posterior border of the ramus and lower border of the mandible.(Fig 3)

(IV) VTO-Mandibular Growth Prediction Symphysis Construction: Slide back along the corpus axis superimposing at new and old PM. Trace the symphysis and draw in mandibular plane. Construct the facial plane from NA to PO.Construct facial axis from CC to GN (where facial plane and mandibular plane cross). (Fig 4)

(V) VTO- Maxillary Growth Prediction: To locate the 'new' maxilla within the face, superimpose at Nasion along the facial plane and divide the distance between 'original' and 'new' Mentons into thirds by drawing two marks. To outline the body of the maxilla, superimpose mark #1 (superior mark) on the original Menton along the facial plane. Trace the palate (with the exception of point A). (Fig 5)

(VI) VTO- Maxillary Growth Prediction Point A Change Related to BA-NA: These are the maximum ranges of Point A change with various mechanics:Point A is altered as a result of growth and mechanics. Point A and a new APO plane are drawn by the following steps: Point A can be altered distally with treatment. Place according to orthopedic problem and treatment objectives. For each mm of distal movement, Point A will drop ½mm. Construct new APo plane.

(VII) VTO-Occlusal Plane Position: Superimpose mark #2 on original Menton and facial plane, then parallel mandibular planes rotating at Menton. Construct occlusal plane (may tip 3 degrees either way depending on Class II or Class III treatment). (Fig. 6)

(VIII) VTO-Dentition Lower Incisor: The lower incisor is placed in relationship to the symphysis of the mandible, the occlusal plane and the APO plane. The arch length requirements and realistic results dictate its location. For this exercise, superimpose on the corpus axis at PM. Place a dot representing the tip of the lower incisor in the ideal position to the new occlusal plane, which is 1 mm above the occlusal plane and 1 mm ahead of the APO plane. Aligning over the original incisor outline or using a template, draw in the lower incisor in the final position as required by arch length. The angle

is 22° at +1mm to the APo plane and + 1 mm to occlusal plane, but the angle increases 2° with each mm of forward compromise. (Fig. 7)

(IX) VTO-Dentition Lower Molar: Without treatment, the lower molar will erupt directly upward to the new occlusal plane. With treatment, 1mm of molar movement equals 2mm of arch length. We moved the lower incisor forward 2mm in this case. There was also 4mm of leeway space. Therefore, the following calculation allows us to move the lower molar forward 4mm on each side. Superimpose the lower molar on the new occlusal plane at the molar (*), slide forward 4mm, upright molar and draw it in. (Fig. 8)

(X) VTO-Dentition Upper Molar: Return to the first tracing Trace the upper molar in good Class I position to the lower molar. Use the old molar as a template.Example of using the upper molar as a template.

(XI) VTO-Dentition Upper Incisor: Place upper incisor in good overbite-overjet position(2½mm overbite, 2½mm overjet) with an interincisal angle of 130° ± 10°. Open bite patterns at a greater angle, deep bite patterns at a lesser angle.Trace the upper incisor in its proper relationship, aligning over the original incisor or by use of a template.Example of using the upper incisor as a template. (Fig. 9)

(XII) VTO-Soft Tissue Nose: Superimpose at Nasion along the, facial plane. Trace bridge of nose. Superimpose at anterior nasal spine (ANS) along the palatal plane. Move prediction 'back' 1mm per year (therefore, 2mm in this case) along the palatal plane. Trace tip of nose fading into bridge. (Fig. 10)

(XIII) VTO-Soft Tissue Point A and Upper Lip: Superimpose along the facial plane at the occlusal plane. Using the same technique as for marking the symphysis, divide the horizontal distance between the 'original' and 'new' upper incisor tips into thirds by using two marks. Soft tissue Point A remains in the same relation to Point A as in the original tracing. Superimpose new and old bony Point A, and make a mark at soft tissue Point A. Keeping the occlusal planes parallel, superimpose mark # 1 (posterior mark) on the tip of the original incisor (slide forward 2/3rds).Trace upper lip connecting with soft tissue Point A. (Fig. 11)

(XIV) VTO-Soft Tissue Lower Lip, Point B, and Soft Tissue Chin: In constructing the lower lip, we bisect the overjet and overbite of the original tracing and mark the point. We then bisect the overjet and overbite of the VTO and mark the point. Superimpose interincisal points, keeping occlusal planes parallel. Trace lower lip and soft tissue B point. The soft tissue below the lower lip remains in the same relation to point B as in the original tracing. Soft tissue point B drops down as the lower lip recontours.

(XV) VTO-Completed Visual Treatment Objective: Superimpose on the symphyses, and arrange the soft tissue of the chin. It 'drops down' and should I be evenly distributed over the symphysis taking into consideration reduction of strain and bite opening. If you have completed the steps, you now have your Visual Treatment Objective. Take your VTO and superimpose it in the five superimposition areas to establish your individual objectives for this case. (Fig. 12)

2. Holdaway's Method [10]

Step I: The first step is to place a clean sheet of tracing material over the original tracing, copying.

(1) the frontonasal area, both hard- and soft-tissue, with the soft-tissue nose carried down to near the point where the outline of the nose starts to change directions(2) the sella-nasion line(3) the nasion-point A line. (Fig. 13)

Step II: First, superimpose on the SN line and move the tracing to show expected growth (0.66 to 0.75 mm per year unless a pubertal growth spurt is expected from wrist plate studies).Second, copy the outline of sella. Third, either copy or change the facial axis (Ricketts' foramen rotundum to gnathion) as you expect it to behave according to the facial type of the patient and the treatment mechanics that you customarily use in such cases. (The facial axis line is usually opened about 1°, but it may even be closed if one is confident that mandibular growth of the forward rotational type will occur during treatment.) Note: It is important to understand that the prediction of growth at nasion, along the SN line, is actually an overall prediction for all midfacial structures, including the nasal bone, the maxilla, and the soft tissues. (Fig 14)

Step III: First, superimpose the VTO facial axis on the original and move the VTO up so that the VTO SN line is above the original SN. The amount of movement will usually be 3 mm per year of growth, except in accelerated growth-spurt periods. (Note: since the facial axis may be opened or closed as judged from the facial pattern, the SN lines will not be parallel if we have changed the facial axis.) Second, copy the anterior portion of the mandible, including the symphysis and anterior half of the lower border. Also draw the soft-tissue chin, eliminating any hypertonicity evident in the mentalis area. (Slightly round out this area.)Third, copy the Downs mandibular plane. (Fig 15)

Step IV : First, superimpose on the mandibular plane and move the VTO forward until the original sella and the VTO sella are in a vertical relation. Next, with the tracing in this position, copy the gonial angle, the posterior border, and the ramus. Finally, superimpose on sella to complete the condyle. Note: At this point total vertical height has been forecast, as has the forward location of the chin structures, both hard and soft, and consideration will have been given to effects of treatment mechanics on vertical dimension. One should not open the facial axis more than 1° to 2° because greater opening than this is usually inconsistent with good treatment mechanics. (Fig 16)

Step V: First, superimpose the VTO NA line on the original NA line and move the VTO up until 40% of the total growth is expressed above the SN line and 60% below the mandible. (Note: This may be varied as you perceive the facial type to be short or long.)Second, with the tracing in this position, copy the maxilla to include the posterior two thirds of the hard palate, PNS to ANS to 3 mm below ANS. Third, also with the tracing in this same position, complete the nose outline around the tip to the middle of the inferior surface. Note: The vertical growth of the nose over the usual 18 to 24 months of estimated treatment time keeps pace with the growth from the maxilla vertically to the anterior cranial base. Thus, its relationship to ANS is relatively constant. In some cases there may be an elevation of the nasal bone and greater development of the nasal bulk, but this is difficult to predict and thus some noses will have changed form more than this VTO procedure suggests. (Fig. 17)

Step VI: First, with the VTO still superimposed on the line NA, move the VTO so that vertical growth between the maxilla and the mandible is expressed 50% above the maxilla and 50% below the mandible. Second, with the tracing in this position, copy the occlusal plan. Note: Ideally, the occlusal plane is located about 3 mm below the lip embrasure. This permits the lower lip to envelop the lower third of the crowns of the upper incisor teeth. If the cant of the occlusal plane is correct, it should be maintained. If not, then it can be altered accordingly at this stage. In cases involving short upper lips, it may not be practical to intrude the upper incisors to this extent, but the vertical relationship of the teeth and gingival tissue will be more esthetically pleasing if we can reach this goal. (Fig 18)

Step VII: Note: When there is a uniform distribution of the soft tissues in the profile and the upper lip is of average length, and where the cant of the H line is not adversely affected by excessive facial convexity or concavity, the depth of the superior sulcus measured to the H line is most ideal at 5 mm. A range of 3 to 7 mm allows one to maintain type with short and/or thin lips and long and/or thick lips. Additional refinement of the technique, which covers all of the above, is gained by use of the vertical line from Frankfort plane to the vermilion border of the upper lip, which is ideal at 3 mm with a range from 1 to 4 mm. To find the point along the lower border of the nose outline at which the new H line will intersect it, both perspectives are used in the exceptional cases just mentioned. First, line up a straight-edge tangent to the chin and angle it back to a point where there is a 3 to 3.5 mm measurement to the superior sulcus outline of the original tracing and draw the H line to this. As one redrapes the superior sulcus area to the new tip of the upper lip point, a 5 mm superior sulcus depth develops almost automatically. If you have trouble with this, the use of the Jacobson-Sadowsky lip-contour template is recommended. Second, with the tracing still superimposed on the maxilla and line NA and using the occlusal plane as a guide for the lip

embrasure, draw the upper lip from the vermilion border to the embrasure. Then from the point on the lower border of the nose where its outline stopped on the VTO, draw in the superior sulcus area. This is a gradual draping to the new vermilion border outline. Third, superimpose on line NA and the occlusal plane. Form the lower lip, remembering that from 1 mm behind the H line to 2 mm anterior can be excellent, depending on variations of thickness of the two lips. Again, most cases will fall on the H line or within 0.5 mm of it. Finally, complete the inferior sulcus drape from the lower lip to the chin in a form harmonious with the superior sulcus.(Note: The lips are not expected to have fully adapted to this position in more than about one half of the cases at the time of retention.) (Fig. 19)

Step VIII: First, with the exceptions noted earlier, lip strain that shows up as excessive upper lip taper is our first consideration. The basic lip thickness measurement was 15 mm and the thickness at the vermilion border was 10 mm. One millimeter of taper is normal, leaving a lip strain factor of 4 mm. Next we are concerned with how many millimeters the upper lip is back from its original position. This is measured with the tracings superimposed on line NA and the maxilla. In the present case this also amounts to 4 mm. The third consideration is maxillary incisor 'rebound.' When the maxillary incisors have been retracted 5 mm or more and the case has been slightly overtreated to a near edge-to-edge incisor overbite and overjet relationship, we can expect about 1.5 mm relapse tendency. Obviously, there will be no tendency to move labially in those cases in which the upper incisor is not retracted or in those cases, such as anterior crossbites and/or Class III cases, in which the maxillary incisors have been expanded labially. Here the incisor retraction is significant, and we will use 1.5 mm for incisor rebound. In this particular patient, then, the calculations would be as follows:(1) Elimination of lip strain, 4 mm. (2) Upper lip change, 4 mm. (3) Maxillary incisor rebound, 1.5 mm. Finally, with the tracing still superimposed on line NA and the maxilla, place the maxillary incisor template, taking cognizance of the amount that it is to be repositioned (9.5 mm in this case), its axial inclination, and the relationship of the incisal edge to the occlusal plane, and draw the tooth. (Fig 20)

Step IX: First, superimpose the VTO on the mandibular plane and symphysis. Using the template, reposition the lower incisor to be in ideal retention occlusion with the maxillary incisor, using the occlusal plane as a guide and by tipping the tooth about the apex unless bodily movement is needed to improve the form of the inferior sulcus area. Second, with the tracing in this same position, measure the amount of lingual movement of the lower incisors. Twice this amount is the arch length loss due to lower incisor (uprighting) lingual tipping or gain from labial tipping when indicated. This loss of arch length is now combined with the arch length discrepancy determined from the model to obtain the total arch length discrepancy. (Fig 21)

Step X: With the tracing superimposed on the mandibular plane and symphysis and using the occlusal plane as a vertical guide, draw the lower molar where it must be to eliminate remaining space if extractions must be part of the treatment plan. Note: By using the VTO approach, you will come upon many cases where mesially tipped lower molars can be uprighted to gain all of the model arch length discrepancy when the incisor position is adequate. Distal tipping of lower molars 2.5 mm can allow nonextraction treatment in cases of a model discrepancy of 5 mm. In other cases, especially those having a history of thumb- or lip-sucking or in which serial extraction is contraindicated, the VTO will show that the lower incisors need to be moved forward, thus also increasing arch length and reducing the need to extract. On occasion both approaches can be used. In my opinion, lower incisors should not be moved forward to a point more than 1 mm anterior to the A-pogonion line, as posttreatment stability and long-term periodontal health are usually endangered by so doing. The use of the VTO at this point to study and evaluate anchorage and arch length is one of its great advantages. If the lower molar must be moved anteriorly as much as 3.5 mm, the lower second premolars will be removed. There are cases in which there is an extremely thin alveolar process, particularly those cases that have deficient lower face height where the lower molars seem to get locked up in cortical bone if the second premolars are extracted. Extraction of the second premolars instead of the first premolars actually increases the lower molar anchorage. When these two factors combine as contraindications to forward lower molar movement, it is sometimes better to look at judicious narrowing of the teeth through stripping and polishing than to extract at all. (Fig. 22)

Step XI: First, using the occlusal plane and the lower first molar as a guide, with a tooth template, position the upper first molar in ideal Class I occlusion with the lower first molar. Second, superimposing tracings on the original NA line and the outline of the maxilla, evaluate the extent of upper molar movement. In cases that worked out as lower arch nonextraction cases, one may still need to think about other extraction alternatives in the upper arch, such as upper second molars when good third molar buds are developing or upper first premolars. (Fig. 23)

Step XII: Note: As to how point A changes with incisor retraction, it is imperative that the clinician study the before and after tracings of many cases superimposed on the original NA line and best fit of the maxilla to get the 'feel' for this step. Obviously the change in point A is greater when the upper incisor root apices are moved a considerable distance than when the upper incisors are tipped lingually. More change in A point is also evident when the tracing is superimposed in this manner if we are going to use heavier orthopedic forces, especially in younger patients (in the mixed dentition). When completed, the VTO can be used not only in case analysis and treatment planning, but as we consider movement of the various groups of teeth to correct a malocclusion the mechanical procedures that will be most direct and efficient practially suggest themselves. Mention must also be made of the usefulness of VTOs to monitor treatment from periodic head films. Using all that we think we know about growth and facial types, on occasion we discover that nature has something else in mind and we may need to change the course of our treatment because of an unexpected growth response. As we look at the retention tracing, it is evident that the tooth movement objectives of the VTO were accomplished. The soft-tissue analysis measurements, while greatly improved, still fail to meet the VTO goals, even though the soft-tissue chin position has improved 1°. This is because the lips still have not completely adapted to the tooth movement. There is an increased measurement of the upper lip thickness at the vermilion border from 10 to 16 mm. The H angle has improved from 23° to 14°. However, with a 2 mm convexity, ideally it should be 12°. In the 7-year follow-up shown, the soft-tissue facial angle is an ideal 90°. The superior sulcus form is excellent to both reference lines. The upper lip has 1 mm of normal taper, with a slight decrease in basic thickness. Skeletal convexity is down to 0, and the H angle is ideal at 10°. The upper lip has completed its adaptive changes and has a 1 mm taper. We see the same changes in this patient's facial photographs. (Fig. 24)

How Reliable is Cephalometric Prediction?

Much attention has been devoted to facial esthetics, harmony, and balance as they relate to orthodontics. In essence, well proportioned and balanced soft tissue facial contours presuppose well defined underlying skeletal and dental structures. Angle suggested that with optimal dental occlusion, good facial harmony would result. Many claim that correct positioning of the incisors allows the overlying soft tissues to be in balance and in harmony. The positioning of the mandibular incisors in particular has been cited as being the key to orthodontic diagnosis and treatment planning, because of its effects on esthetics. This is only a hypothesis. Since the positioning of the hard tissues is not necessarily the answer to achievingthe facial balance and harmony, an alternative procedure conceived was that of creating an ideal soft tissue facial balance from a lateral head film and positioning maxillary and mandibular teeth to eliminate lip strain. The short comings are that the estimated growth rates and direction of skeletal tissues during the proposed treatment period are based on past growth increments. No allowance is made for alterations in growth rates or direction which are totally unpredictable. Furthermore the determination of facial

balance for the particular individual being treated as judged from a two dimensional lateral head film tracing is subjective and at best only an estimate. So a video imaging or VTO of what a patient may look like after orthodontic treatment should have a written disclaimer placed on the print out, lest the patient perceive that the VTO is a guaranteed result.

Conclusion

The VTO prediction tracing is an important tool in diagnosis and treatment of dentofacial and craniofacial deformities. It allows for the assessment of facial esthetics, along with planning the appropriate surgical procedures and modifications as needed. Whenever excessive maxillary or mandibular advancements or retractions are considered, the pharyngeal airway needs to be followed closely; thus, an ear, nose, and throat and speech consultation will become part of the treatment in order to avoid future complications. Dental compensations can be considered and treatment planned to eliminate them for optimum results. Finally, the prediction tracing can offer a graphic explanation to the patient of the proposed treatment, to promote better understanding and acceptance of the procedure. The VTO in itself, however, cannot give the total picture of the situation at hand. Many other factors come into play which are not reflected in the prediction. A deficiency in the transverse plane is not considered, necessitating the important role of model surgery in conjunction with the VTO tracing. Of course, a major factor in predicting the correct treatment for a given patient is one's own clinical impression and evaluation, not only of the patient's physical status, but also of his mental attitude.

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