By Ib Nielsen, DDS, MSc
UCSF Orthodontic Program Director

WHAT YOU MAY HAVE FORGOTTEN ABOUT CEPHALOMETRIC ANALYSIS (PART II*)

ANALYSIS OF GENERAL FACIAL GROWTH AND TREATMENT ("STRUCTURAL ANALYSIS")

It is often important during the orthodontic treatment of a patient to be able to monitor the positive and negative changes that may have taken place during treatment. To this end the clinician should be able to comfortably analyze serial headfilms and get reliable information as to the progress of the patient's treatment. It is valuable to be able to distinguish between the skeletal and dental change that have occurred in each of the jaws. The conventional method for such analysis has often been either:

- Individual headfilm analyses with comparison of a series of measured values
- Superimposition of the tracings of two or more headfilms

The first method has limited value as it represents only the change in the measurements. These are frequently minimal and do not give a clear picture of the actual location of the change. The second method using of some kind of superimpositioning technique where two or more films taken in series are compared directly also has its problems. Frequently the headfilms, or tracings thereof, are superimposed using the so-called "best fit" technique so the clinician can see how the face grew. This part of the analysis is often referred to as a general facial growth analysis. In this technique certain cranial base structures are used as the reference structures, typically the Nasion-Sella line, with the films registered at Sella.

HISTORIC METHODS OF SUPERIMPOSITION

To examine growth and treatment changes in the mandible using a best-fit technique, superimposition is made on the lower border of the mandible and registered at the chin. Finally, analysis of maxillary growth has until now mostly been done by superimposing on the nasal floor along a line from anterior to posterior nasal spine (PNS), registered at anterior nasal spine (ANS). These techniques are all flawed due to surface modeling changes of the jawbones over time.

BASIS FOR CURRENT RELEVANT METHODS OF SUPERIMPOSITION

With many studies and using metallic implants as fixed reference markers in the jaws, Björk demonstrated over a period of almost 30 years that there is a clear biological problem with the "best-fit" superimpositioning technique (1955, 1963 and 1972). His studies showed that conventional

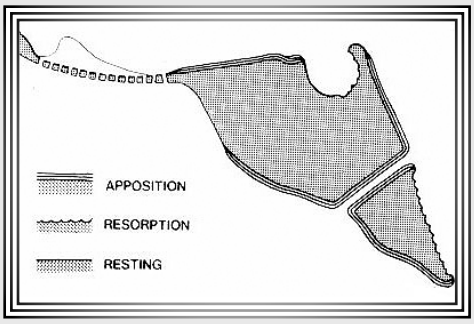

Figure 1

techniques do not take into consideration that the maxilla and mandible often undergo extensive surface modeling during growth. The findings of his studies support the notion that whereas the technique of "best-fit" can work well in non-growing or adult subjects, it should not be used in growing subjects because of these surface changes. Instead, Björk recommended that a so-called "Structural Analysis" should be used where superimposition is made on stable internal structures in the jaws. In the following I shall describe the so-called *"Structural Technique"* for facial growth and treatment analysis. This analysis can work just as well when analyzing conventional cephalometric headfilms, with modern digital headfilms, or with Cone Beam Computed Tomography (CBCT) acquired headfilms.

ANALYSIS OF GENERAL FACIAL GROWTH "STRUCTURAL TECHNIQUE"

To accurately determine general facial growth changes, one superimposes tracings by aligning stable structures

** Part I was published in* PCSO Bulletin*, Summer 2007. –Ed.*

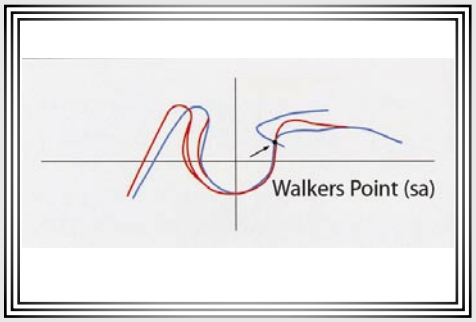

Figure 2

in the anterior and median cranial base that have completed growth before ages six to seven. The scientific basis for this technique is supported by studies using histology and histochemistry information as published by Melsen (1971) *(Fig. 1).* Her studies on autopsy material of young individuals of known age showed that certain structures in the anterior and median cranial base have finished their growth at around the age of seven. These structures include the cribiform plate (1), the median border of the orbital roof (2), and the inner plate of the frontal bone (3). Walker further found that the intersection point of the anterior wall of Sella Turcica and the anterior Clinoid process is stable from an early age (indicated by an arrow). *Fig. 2* shows the most typical modeling changes

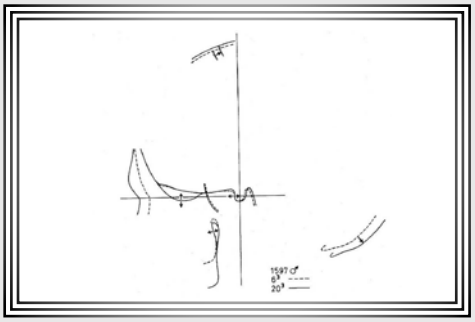

Figure 3

that occur at sella during the growth period. Notice that there is resorption of the posterior wall, which results in a downward backward shift of the center of sella turcica over time. Also, that the anterior wall remains unchanged. The arrows indicate the anterior clinoid process and Walker's point, also called Sella Anterior (sa). This intersection point is similar to articulare in that it exists only on the lateral headfilm. Further structures that can be used include the inner surface of the frontal bone, which is stable from an early age, whereas the outer surface has some appositional change, especially around nasion. As a result, during growth, anatomical nasion can be displaced slightly up or down. Finally, the anterior walls of the median cranial fossa (the greater wings of the sphenoid) can also be used, as well as the ethmoid cells. An additional important point, brought out by Björk's research, is that certain structures that have not yet completed their growth behave in a logical way. For instance, the posterior cranial base as represented by basion and the lateral by articulare move in a logical manner as a result of growth. Similarly, the occipital bone grows in a downward and outward direction, expanding the brain case almost until growth is completed. Another structure to observe is the pterygopalatine fissure that generally displaces in a vertical direction over time and does not move in the anterior or posterior direction. By including sequences of logical change of certain anatomical structures it is possible to reduce rotational errors when analyzing serial headfilms and address the criticisms, raised in the past, of too much variability. The structures to observe are seen in the illustration in *Fig. 3.*

In a previous article, Houston et al. (1985) claimed that nasion-sella superimposition was generally associated with too much error, however, they did not use the exact same structures listed above nor did they observe a logical sequence of growth changes, which helps reduce rotational errors considerably.

The illustration in *Fig. 4* shows superimposition of the tracings of two headfilms on the stable structures of the cranial base using the so-called *"structural superimposition."* The headfilms are aligned on the stable structures in the anterior and median cranial base registered at the anterior wall of sella turcica. Notice the skeletal change of the maxilla and mandible relative to the cranial base and the dental changes that occurred relative to the face. Part of the outer surface of the occipital bone is included to reduce rotational errors as this bone displaces in an outward-down-

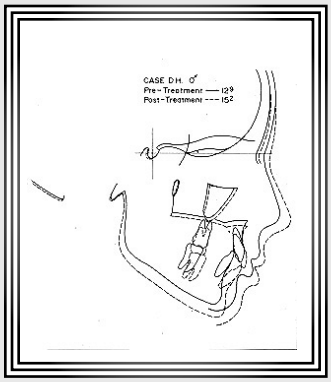

Figure 4

Figure 5

ward direction as seen here. An interesting aspect of the analysis is the location of the upper and lower first molars. To obtain the correct location of these teeth we use occlusograms scanned from the study casts. By tracing the scanned models and then measuring the distance from the incisors to the mesial of the first molars, we are able to get the correct placement of these teeth. In cases where there is a magnification problem between the conventional headfilm—that often are magnified about 10%—and the model scan, we adjust the measurement accordingly before tracing the molar positions. *Fig.5* shows a model scan with the distance measured.

ANALYSIS OF CHANGES IN SAGITTAL JAW RELATIONSHIP

In some cases a simple analysis to determine the changes in the sagittal jaw relationship can be very helpful. This is especially the case when a clinician is concerned with some unexpected changes in jaw position of the mandible and unforeseen changes in the occlusion during treatment, in these instances a simple analysis can be very useful. One way to check the change in the jaw relationship between the maxilla and mandible, and determine if a given treatment is progressing as expected, is to make two simple tracings of each of the headfilms that include only the necessary structures. These tracings include only the nasion sella and nasion sella perpendicular lines and the anterior outline of the maxilla i.e. anterior nasal spine as seen in *Fig.6*. The outline of the chin is then traced and both tracings are overlaid or superimposed on anterior nasal spine. It is important to remember to rotate the second films tracing so that the nasion sella lines are parallel. The tracing seen in Fig. 6 shows the relative change in sagittal and vertical jaw relationship. Note that the tracing does not include any rotational change that may have occurred as the nasion and nasion sella lines were aligned in a parallel fashion. The tracings in Fig. 4 show an example of this analysis in a treated patient and includes three stages; before and

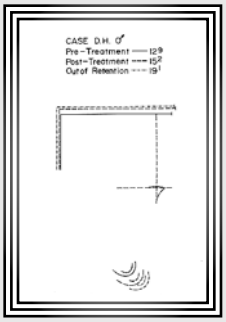

Figure 6

after treatment and out of retention. As seen here the mandibular growth direction was downward and forward during treatment and post-treatment in relation to the maxilla and this is in many cases helpful information to the clinician.

There are several other aspects of the "structural analysis" growth and treatment analysis that we have not dealt with in this brief report due to space limitations. In a future article we will describe the analysis of maxillary and mandibular growth and treatment changes and explain how we can include occlusograms to get three-dimensional illustrations of the changes in maxilla and mandible during treatment.

LITERATURE

Björk, A. Facial growth in man studied with the aid of metallic implants. Acta Odontol. Scand. 13:9-34, 1955.

Björk, A. Variations in the growth pattern of the human mandible: A longitudinal radiographic study by the implant method. J. Dent. Res. 42: 400-411, 1963.

Björk, A. and Skieller, V. Facial development and tooth eruption. An implant study at the age of puberty. Am. J. Orthod. 62: 339-383, 1972.

Melsen, B. The cranial base. The postnatal development of the cranial base studied histologically on human autopsy material. Acta Odontol. Scand. 32: suppl. 62, 1974.

Houston, W. J. B., and Lee, R. T. Accuracy of different methods of radiographic superimposition on cranial base structures. Eur. J. Orthod. 7: 127-135, 1987.