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# A Frontal Asymmetry Analysis

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**DUANE C. GRUMMONS, DDS, MSD**

**MARTIN A. KAPPEYNE VAN DE COPPELLO**

Since the advent of cephalometric radiography, orthodontists have focused on the lateral x-ray as their primary source of patient skeletal and dentoalveolar data. However, the frontal (PA) and basilar views also contain valuable information for diagnosis and treatment planning procedures. Various dental and skeletal widths and skeletal asymmetries that are not available from the lateral cephalogram can be quantified from a frontal radiograph (Fig. 1).

Orthodontists have traditionally been reluctant to use frontal radiographs for several reasons: difficulty in reproducing head posture; difficulty in identifying landmarks because of superimposed structures or poor radiographic technique; and concern about exposure to radiation. In addition, many clinicians have never been instructed in the use of frontal data.

Today more adult patients are being treated than ever before, with more sophisticated treatment goals. Identification of transverse and skeletal asymmetries from the frontal radiograph can be integrated with submental vertex and occlusal x-ray data (Fig. 2) to plan a multidisciplinary approach to adult treatment. Such frontal and asymmetry information is vitally important in:

1. orthodontic surgery planning (lateral and frontal VTOs);

2. differential tooth eruption with segmental TMJ splint therapy; and

3. functional jaw orthopedics including three dimensional improvements in facial or dental proportions or symmetry.

## Limitations of Previous Analyses

Frontal cephalometric analyses have been used for several decades. Several were developed primarily for surgical use.[1-3] More orthodontically oriented analyses were proposed by Ricketts,[4,5] Owen,[6] Fish and Epker,[7] Williamson,[8] and Mongini.[9] Each of these analyses provides information but has limitations.

Computerized data by El-Mangoury et al.[10] revealed that skeletal landmarks were more reliable than the dental landmarks in anteroposterior cephalometrics. The most reliable skeletal landmarks were menton and Point B; the mandibular canine was the most reliable dental landmark. The least reliable dental landmarks were the mandibular first molars and the maxillary canine. The zygomatic-frontal suture was the most unreliable skeletal landmark.

The selection of a reliable vertical baseline is important. Any choice of a vertical plane, however, can preclude the accurate determination of specific locations of asymmetry. Beck[11] examined a number of proposed axes[12-16] and decided to use two axes through basion perpendicular--to lines connecting the two foramina rotunda or the two foramina spinosa.

Angular measurements and ratios are also absent from previous frontal analyses. Such measurements are preferred over distances in many widely used lateral analyses because they eliminate the effects of head size and magnification.

Although previous frontal analyses have been related to a lateral analysis for three-dimensional representation of the patient's head, they omit any consideration of volume. Nor do they measure mandibular morphology, which can be seen clinically to play the major role in asymmetries.

## Frontal Asymmetry Analysis

A new PA analysis has been developed to provide clinically relevant information about specific locations and amounts of facial asymmetry. This information can be correlated with lateral cephalometric data to complete a three-dimensional facial assessment. Its purpose is comparative and quantitative, not normative.

Several standard points and planes from the PA radiograph have been chosen,[5] and additional points have been selected on the basis of their reliability in determining asymmetry and their ease of location on film. Abbreviations used are shown in Figure 3. There are two forms of this Grummons analysis currently available-- comprehensive and summary.

### *Horizontal Planes*

Four planes are drawn to show the degree of parallelism and symmetry of the facial structures (Fig. 4). Three planes connect the medial aspects of the zygomatic frontal sutures (Z-Z), the centers of the zygomatic arches (ZA), and the medial aspects of the jugal processes (J). Another plane is drawn at menton parallel to the Z plane.

MSR normally runs vertically from Cg through ANS to the chin area, and will typically be nearly perpendicular to the Z plane. MSR has been selected as a key reference line because it closely follows the visual plane formed by subnasale and the midpoints between the eyes and eyebrows. The relation of MSR to the center of the cervical vertebrae can alert the clinician to possible head rotation when the PA headfilm was taken.

Construction of MSR may have to be modified if the patient has anatomic variations in the upper and middle facial regions (Fig. 5). If the location of Cg is in question, an alternative method of drawing MSR is to draw a line from the midpoint of the Z plane through ANS. If there is upper facial asymmetry, MSR can be drawn as a line from the midpoint of the Z plane through the midpoint of an Fr-Fr line.

What may appear as asymmetry on the film may be quite different from the patient's actual asymmetry if the head had to tip or rotate to conform to the cephalostat. To confirm centered head position, extend the Z plane beyond the intersection with the lateral cranial borders on both sides, and compare the distances between Z and the cranial borders.

Head rotation is usually caused by the ear rods being placed into asymmetrical external auditory canals. In such a patient, only one ear rod should be inserted, and the midsagittal plane should be lined up perpendicular to the radiographic cassette. The second rod can then be placed lightly against the skin to give the patient a sensory reference.

To insure correct head tilt when taking the radiograph, check the patient from the side to see that the Frankfort plane (from the infraorbital margin to the external auditory canal) is close to horizontal. The patient should be looking straight ahead or even slightly downward.
Another technique is to suspend a plumb line, made from thin piano wire and a weight, from the x-ray cassette. This line will then appear as a true vertical reference line on the radiographs (Fig. 6).

### *Mandibular Morphology*
Left and right triangles are formed from the heads of the condylar processes or the condyles (Co), the antegonial notches (Ag), and menton. These are split by the ANS-Me line and compared (Fig. 7). ANS-Me parallels the visual dividing line from subnasale to soft tissue menton in the lower face.

Linear values, angles, and anatomy can be measured. Like the horizontal planes, these data are quite sensitive to head rotation.

### *Volumetric Comparison*
Two "volumes" (polygons) are calculated from the area defined by each Co-Ag-Me and the intersection with a perpendicular from Co to MSR (Fig. 8). A computer can superimpose one polygon upon the other to provide a percentile value of symmetry.[17]

### *Maxillo-Mandibular Comparison of Asymmetry*
Perpendiculars are drawn to MSR from J and Ag, and connecting lines from Cg to J and Ag (Fig. 9). This produces two pairs of triangles, each pair bisected by MSR. If perfect symmetry is present, the four triangles become two, J-Cg-J and Ag-Cg-Ag. Similar to the triangles proposed by Butow and van der Walt,[1] this is a quick and easy method to assess symmetries in both jaws.

### *Linear Asymmetries*
The vertical offset as well as the linear distance is measured from MSR to Co, NC, J, Ag, and Me (Fig. 10). The computer printout lists left and right values and the differences between them (Fig. 11).

### *Maxillo-Mandibular Relation*
To allow tracing of the functional posterior occlusal plane, an .014" wire is placed across the mesio-occlusal areas of the maxillary first molars. The wire should extend about 3mm buccally to make it easy to recognize on the headfilm (Fig. 6).

Distances are measured from the buccal cusps of the upper first molars (on the occlusal plane) along the J perpendiculars. The Ag plane, MSR, and the ANS-Me plane are also drawn to depict the dental compensations for any skeletal asymmetries in the horizontal or vertical planes (maxillo-mandibular imbalance). Midline asymmetries of the upper and lower incisors and Me-MSR are also provided (Fig. 12).

### *Frontal Vertical Proportions*

Skeletal and dental measurements are made along the Cg-Me line with divisions at ANS, A1, and B1 (Fig. 13). The following ratios are calculated (Fig. 11):

Upper facial ratio--Cg-ANS/Cg-Me

Lower facial ratio--ANS-Me/Cg-Me

Maxillary ratio--ANS-A1/ANS-Me

Total maxillary ratio--ANS-A1/Cg-Me

Mandibular ratio--B1-Me/ANS-Me

Total mandibular ratio--B1-Me/Cg-Me

Maxillo-mandibular ratio--ANS-A1/B1-Me

These values can be compared with common facial esthetic ratios and measurements.[18,19] The final product of the Comprehensive Frontal Asymmetry Analysis is a summary data sheet (Fig. 11), accompanied by three tracings (Figs. 12,13,14).

The horizontal planes, mandibular morphology, and maxillo-mandibular comparisons have been combined to produce the Summary Facial Asymmetry Analysis, which by intention displays less data (Fig. 15). This provides a practical summary of the patient's frontal asymmetry, emphasizing key dentoalveolar and skeletal factors that influence treatment decisions.

### Case Report

A malocclusion is typically more Class II with a higher occlusal plane on the asymmetric side. As this side is advanced and/or positioned inferiorly in the face--with orthognathic surgery, functional appliances, or splints--the teeth further separate on that side. As skeletal symmetry is established, differential occlusal plane leveling and facial balance result. Post-surgically, orthodontics with segmental stabilizing splints can be used to establish the best three-dimensional results.

When TMJ disorders coexist, these may require repositioning-stabilizing splint therapy first for optimal joint function. Then an interocclusal index (bite registration) can be made for x-ray procedures and for articulated model analysis. Thus, mandibular positioning can be controlled during the x-ray process.

If the patient were permitted to close into habitual deflective centric occlusion with TMJ displacement, this would locate the mandible further off center. For example, a 2mm change in TMJ position may swing the mandible 2-3mm at the midline. This would affect the frontal analysis and treatment planning--particularly when orthognathic surgery in the maxilla or in both jaws was intended. The greatest effect is in the transverse and vertical aspects of the frontal assessment.

The case of a 30-year-old female patient illustrates how the frontal analysis can contribute to treatment of such a case. This patient had asymmetry in the middle and lower facial thirds, moderate maxillary vertical hyperplasia with true mandibular skeletal deficiency, and associated Class II malocclusion (Fig. 16).

The patient's maxillary occlusal plane was leveled with surgery, and the mandibular occlusal plane was differentially leveled postsurgically with segmental splints and orthodontics (Figs. 17A and 17B). Optimal facial balance with skeletal symmetry and beauty were achieved, and a posterior condylar displacement on the right side was optimized with excellent range of motion established (Fig. 18).

## Conclusion

Head rotation and improper construction of MSR can reduce the effectiveness of this analysis. In addition, measurements are subject to distortion from projection technique and should therefore be used comparatively rather than quantitatively.

This analysis is intended to provide a practical, functional method of determining the locations and amounts of facial asymmetry. It is of greatest clinical value when integrated with data from lateral and submental vertex radiographs.

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