Why WITS? Why not a way beyond?

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Abstract

Introduction: WITS appraisal is a common parameter in cephalometrics to assess maxillo-mandibular skeletal relationship as an adjunct to angle ANB. The high variability of the WITS appraisal is attributable to difficulties or inaccuracies in identifying the occlusal plane or variations due to tooth eruption, dental development or treatment changes by vertical movement of incisors, molars, or both. **Aim:** An extracranial reference line common to both denture bases, instead of the occlusal plane is proposed to assess antero-posterior jaw relationships. **Materials and Methods:** A true vertical obtained by plumb line was recorded, while taking the cephalogram for 40 subjects. A line drawn perpendicular to this true vertical gave a stable and reproducible extracranial true horizontal (HOR) reference line. The linear distance between perpendiculars from points A and B was measured as an adjunct to angle ANB. **Result:** The Pearson’s product moment correlation coefficient calculated for the entire sample indicated higher correlation coefficient ($r = 0.8712$) for the linear measurements on HOR (AH-BH) with respect to the angle ANB when compared with the WITS readings (AO-BO) ($r = 0.549$). **Conclusion:** The horizontal appraisal method proposed eliminates the demerits of the occlusal plane and has the merits of simplicity and accuracy in comparison to WITS appraisal.

Keywords: Antero-posterior jaw relationship, cephalometrics, cephalostat, extracranial reference line, occlusal plane, true horizontal, Witwatersrand university, Johannesburg, South Africa appraisal

Introduction

The very moment a clinician observes the patient for the orthodontic treatment, there is an undisputed importance of profile and antero-posterior jaw relationship. Freeman[1] stated that, even before Angle introduced his classification of malocclusion to the profession in the early 1900s, the antero-posterior relationship of mandible to the maxilla was the most important diagnostic criterion. The “WITS” appraisal of jaw disharmony is not an analysis in isolation by itself. It is considered as a diagnostic tool to assess the severity or degree of antero-posterior jaw disharmony on a lateral cephalogram. There are inherent inconsistencies, while relating jaws with respect to cranial reference planes because of deviations in craniofacial morphology. The craniofacial skeletal variations include: (1) The antero-posterior spatial relationship of nasion relative to jaws and (2) the rotational effect of the jaws relative to cranial reference planes.[2]

Jacobson[2] (and Harvey Jenkins) had drawn perpendiculars on a lateral cephalogram tracing from hard tissue points A and B on the maxilla and mandible, respectively, to the occlusal plane to obtain a measurement that was less affected by variations in craniofacial physiognomy [Figure 1]. The linear distance between the points of contact of the perpendiculars on the occlusal plane, AO and BO, indicated the skeletal sagittal jaw relationship. This came to be known as the WITS (Witwatersrand University, Johannesburg, South Africa) appraisal.

The WITS appraisal avoids the use of landmark nasion, unlike angle ANB, thus reduces the effects of jaw growth rotations. However it uses the occlusal plane, which is a dental parameter, to describe the skeletal discrepancies. However, tooth eruption and dental development easily affect the occlusal plane [Figure 2].[3]

The high degree of variability of WITS is undisputed because (1) The occlusal plane can be easily affected by tooth eruption and dental development.[3] (2) There are difficulties or inaccuracies in identification of the occlusal plane.[3] (3) The inclination of the occlusal plane may change by the vertical movement of incisors, molars, or both during treatment.[3,9,10]

Therefore, using a reference plane that itself is subject to change due to treatment mechanics is not justified as...
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illuminated in Figure 3a-c. It is not a good idea to compare the sagittal relation of maxilla and mandible on a reference line, which is not constant before and after treatment. It will indeed indicate fallacious relationship. Other reference planes, which depend upon cranial morphology, are not essentially reliable for assessment because of changes in cranial base. To evaluate the antero-posterior jaw relationships, there should be an extracranial reference line common to both denture bases.

This study was designed to check the reliability of WITS appraisal and propose a simple and accurate new method, to obtain an extracranial reference line to overcome the demerits of using occlusal plane in WITS appraisal as an adjunct to assess antero-posterior skeletal discrepancy.

Materials and Methods

The study sample consisted of 40 subjects (20 females and 20 males) were in the age ranging from 21 to 27 years. All the subjects had competent lips with a class I molar relationship irrespective of the skeletal basal relationship. The exclusion criteria used were previous orthodontic and/or prosthetic treatment. They were positioned in the cephalostat by the same operator and standardized lateral cephalograms were taken with a digital radiograph machine.

Two methods have been described to obtain a true vertical: Using a fluid level device or plumb line method. According to the basic laws of physics, any object when freely suspended under gravity would remain perpendicular to the floor. The latter was used in this study. A true vertical line was recorded in the midsagittal plane, while taking the cephalogram. A 0.009" stainless steel wire was used to suspend a metal bob weighing 100 g [Figure 4]. The radiograph was taken in natural head position (NHP) [Figure 5], by positioning the patient in the cephalometer and asking him or her to look straight ahead into a mirror. It was ensured that the pupil is in the middle of the eye.

Once the patient is looking straight ahead, the bilateral ear rods were placed immediately in front of the tragus, such that they would lightly contact the skin. This would ensure that the head is supported in the transverse plane. The patient was calm and at ease, and the head was well-centered without any tilting or tipping. Once the correct position of the patient is verified from the front, the nosepiece was then positioned in front of nasion, again maintaining light contact with the skin, to establish support in the vertical plane. The three light contact points stabilize the patient in the NHP.[11]

Thus, a radio-opaque line depicting true vertical was obtained on the radiograph [Figure 6]. Any line drawn perpendicular to this true vertical gives a true horizontal (HOR). The method simply gives an extracranial HOR reference line, common to both denture bases. Perpendiculars from point A and point B were dropped on the HOR, and the linear distance was measured on standardized cephalograms [Figure 7]. This “horizontal appraisal” would give relative position of denture bases as an adjunct to angle ANB.

Results

After the tracings were made, linear measurements were recorded on both occlusal plane (AO-BO WITS appraisal) and HOR plane (AH-BH horizontal appraisal) [Tables 1 and 2]. Both linear measurements were then correlated to their respective angle ANB. A higher correlation was observed between angle ANB and AH-BH distance, that is, horizontal appraisal compared with WITS appraisal.

The Pearson’s product moment correlation coefficient calculated for the entire sample indicated a higher correlation for females ($r = 0.7557$) as well as males.

Figure 1: Perpendicualrs drawn on a lateral cephalogram tracing from points A and B on the maxilla and mandible, respectively, to the occlusal plane to obtain a measurement; WITS Appraisal. Courtesy: Jacobson A. The “Wits” appraisal of jaw disharmony. Am J Orthod 1975;67:125-38

Figure 2: The effects of WITS value of differences in the angle of occlusal plane and the distance between point A and B. Courtesy: Jacobson

Figure 2: The effects of WITS value of differences in the angle of occlusal plane and the distance between point A and B. Courtesy: Jacobson A. The “Wits” appraisal of jaw disharmony. Am J Orthod 1975;67:125-38
(r = 0.7830) of linear measurements on HOR with respect to the angle ANB when compared with the WITS readings for females (r = 0.4429) and males (r = 0.5023). Moreover, the correlation was higher for both the readings in males. Furthermore, an overall higher correlation coefficient (r = 0.8712) was observed for the entire sample for the linear measurements on HOR (AH-BH) compared with AO-BO (r = 0.549).

Discussion

Riedel[12] presented a number of cephalometric parameters, including angle ANB. It is by far universally accepted and most commonly used parameter to assess antero-posterior jaw relationship. However, Chinappi et al.,[13] Jacobson,[2,14] Hussels and Nanda,[3] and Järvinen[15] emphasized that the assessment of skeletal discrepancies in the sagittal plane based on uncorrected angle ANB can be flawed. ANB angle is influenced by a number of environmental factors and thus
a diagnosis based on this angle may be ambiguous. Some authors have confirmed geometrically that the ANB angle can be changed, although the intermaxillary relationships were unchanged. The following factors have been accounted to influence the ANB angle.

1. The patient’s age. The ANB angle has a definite tendency to decrease with age.
2. The change of the spatial position of the nasion either in a vertical or antero-posterior direction, or both
3. The upward or downward rotation of the SN line
4. The upward or downward rotation of the jaws
5. The change in the angle SN to the occlusal plane
6. The degree of facial prognathism.

Jacobson suggested the use of the WITS appraisal to assess the skeletal discrepancy. Since the correction of angle ANB is based on the WITS appraisal being equal to zero, the occlusal plane is the weak point in this evaluation and not necessarily reliable. According to Demisch et al., the landmarks of the occlusal plane are difficult to find and the occlusal plane is influenced by both skeletal and dental parameters.

To eliminate the great variations in the occlusal plane, Chang[5] reported a linear measurement of the distance between points A and B projected onto the Frankfort horizontal plane. The points of contact of the perpendiculars on the Frankfort horizontal plane from points A and B were marked AF and BF, respectively, and this linear measurement was labeled the AF-BF distance. But eventually the Frankfurt Plane also depends on the bilateral Porion and Orbitale, which can be subject to anatomical variations.

According to Kim and Vietas,[18] deviations in the dentofacial complex are not influenced by a single factor; thus, a combination of several different measurements may be more consistent for diagnosis. They suggested a measurement formula, the antero-posterior dysplasia indicator, which is a resultant reading calculated from the facial angle plus or minus the A-B plane angle and again plus or minus the palatal plane angle. This again is a calculative method not a straightforward assessment.

### Table 1: Correlation of angle ANB with WITS appraisal and horizontal appraisal in females

| Female | Angle ANB (°) | AO-BO (mm) (on occlusal plane) | AH-BH (mm) (on true horizontal) |
|--------|--------------|-------------------------------|-------------------------------|
| F1     | 3.5          | 1.5                           | 4.5                           |
| F2     | 2.5          | 2.5                           | 5.5                           |
| F3     | 1.5          | -2.5                          | 1.5                           |
| F4     | 0.5          | 1.5                           | 2.5                           |
| F5     | 1.0          | -2.3                          | -0.5                          |
| F6     | 2.0          | -1.5                          | 4.0                           |
| F7     | 3.5          | 1.5                           | 5.5                           |
| F8     | 3.0          | 2.0                           | 4.5                           |
| F9     | 2.0          | 1.5                           | 3.5                           |
| F10    | 2.5          | -1.5                          | 4.0                           |
| F11    | 3.0          | 4.5                           | 4.5                           |
| F12    | 2.5          | 2.3                           | 3.5                           |
| F13    | 3.5          | 3.5                           | 4.5                           |
| F14    | 2.0          | -1.5                          | 2.5                           |
| F15    | 4.0          | 2.5                           | 4.5                           |
| F16    | 1.5          | 2.5                           | 3.5                           |
| F17    | 2.5          | 2.0                           | 3.5                           |
| F18    | 3.5          | -1.5                          | 4.0                           |
| F19    | 3.0          | 2.5                           | 3.5                           |
| F20    | 1.0          | -1.0                          | 1.5                           |
| Sum    | 48.50        | 18.500                        | 70.500                        |
| Average| 2.43         | 0.925                         | 3.525                         |
| SD     | 0.9770       | 2.0997                        | 1.4462                        |
| Pearson| 0.4429       | 0.7557                        |                                |

SD: Standard deviation

### Table 2: Correlation of angle ANB with WITS appraisal and horizontal appraisal in males and overall sample

| Male | Angle ANB (°) | AO-BO (mm) (on occlusal plane) | AH-BH (mm) (on true horizontal) |
|------|--------------|-------------------------------|-------------------------------|
| M1   | 5.0          | 6.5                           | 8.5                           |
| M2   | 4.5          | -1.5                          | 9.0                           |
| M3   | 2.0          | -3.0                          | 3.0                           |
| M4   | 3.0          | 1.0                           | 0.5                           |
| M5   | 4.0          | 0.5                           | 5.5                           |
| M6   | 1.5          | -2.0                          | 2.5                           |
| M7   | 3.5          | -2.5                          | 6.5                           |
| M8   | 2.5          | 1.0                           | 4.5                           |
| M9   | 1.0          | -1.5                          | -2.0                          |
| M10  | 3.0          | 2.0                           | 3.5                           |
| M11  | 4.0          | 2.5                           | 6.5                           |
| M12  | 1.5          | -2.0                          | -1.0                          |
| M13  | 2.5          | -2.5                          | 5.5                           |
| M14  | 1.5          | 2.0                           | 4.5                           |
| M15  | 2.0          | 1.5                           | 3.0                           |
| M16  | 2.5          | 3.0                           | 4.0                           |
| M17  | 3.5          | 5.0                           | 6.5                           |
| M18  | 1.0          | -1.5                          | 3.5                           |
| M19  | 3.5          | 4.0                           | 6.5                           |
| M20  | 3.0          | 4.0                           | 5.0                           |
| Sum  | 55.0         | 16.5                          | 85.5                          |
| Average| 2.8         | 0.8                           | 4.3                           |
| SD   | 1.15280      | 2.8064                        | 2.8353                        |
| Pearson| 0.5023      | 0.7830                        |                                |
| Pearson overall| 0.5490 | 0.8712                        |                                |

SD: Standard deviation
Various cranial reference planes have been used as base lines from which to determine degrees of jaw dysplasia. De Coster superimposed on outlines of the floor of the brain case from planum sphenoidale forward into the anterior cranial edge of the sphen-occipital synchondrosis over sella, drawing a reference line from there to nasion. Broadbent developed the Bolton triangle, and the same triangle was modified by the substitution of basion for the Bolton point.

All of the above reference planes are affected by cranial morphology and relate the jaws to the cranium. Measurements from the cranial base, however, do not necessarily provide a reliable evaluation of antero-posterior jaw relationship in the dentofacial complex. The line of reference from which antero-posterior jaw relationships should be assessed, must be extracranial and relate to true vertical or a horizontal perpendicular to it.

Relating the jaws to an extracranial perpendicular may establish antero-posterior jaw relationship which is important from an aesthetic standpoint. However, when one is attempting to determine the severity of antero-posterior jaw disharmony or dysplasia, the jaws must be related to each other instead of just to cranial or extracranial landmarks. A reference plane, common to both alveolar bases is the occlusal plane. When relating the jaws to this common plane, clockwise or counter clockwise rotation of the jaws relative to cranial or extracranial reference planes will in no way affect the over-all assessment of severity of jaw disharmony.

Authors like Lundström and Lundström[19] have demonstrated that HOR represents a more stable base line for cephalometric analysis than any of the other reference lines used in their study. The large deviation of the reference lines to the HOR shows that the inclination of S-N does not correspond to head posture in a reliable way. Several authors have demonstrated HOR passing through Sella or other stable cranial landmarks. Since Ricketts[20] mentions that Xi point is a stable landmark and lies along the occlusal plane [Figure 8], in the present study, HOR was passed through Xi point to check if there was any difference in readings [Figure 9]. Since same readings were obtained, it was chosen to avoid using it and project HOR below the chin where as such no overlapping and obstruction by cranial structures is present to obscure the readings.

In the present study, on statistical evaluation of the cephalometric readings, it was observed that there was a significant difference between the linear measurements on the occlusal plane and HOR plane. The Pearson’s product moment correlation coefficient (r = 0.8712) was observed higher for the entire sample for the linear measurements on HOR (AH-BH) compared to AO-BO (r = 0.549).

The review of the literature repeatedly accepts the weakness in accuracy and reliability of the occlusal plane as a reference line. Antero-posterior skeletal relationship of both jaws is most frequently required for patient assessment. An absolute linear measurement of the antero-posterior discrepancy is desirable to assess pretreatment and posttreatment. The findings of this study suggest the use of the horizontal appraisal as opposed to WITS appraisal.

A fixed true vertical can vary with cephalometric film orientation or floor plane or loosened machine arm. An alternative of re-designing the cephalostat is by supplementing it with a fine metallic, radio-opaque retractable cord with an attached weight. It should be incorporated in cephalostat itself in front of the nasion support rod, so that when it is freely suspended, a true vertical (plumb line method) extracranial reference line is obtained on each cephalogram.

Nowadays there is a paradigm shift to assess the patient photographically, in NHP and three dimensionally, especially for growth modifications, orthognathic surgeries, and cosmetic reconstructions. The diagnostic information should be easily communicated to lay persons, such as patients and parents, and to general dentists who may not understand the intricacies of cephalometrics. Explaining the dental or skeletal parameters of malocclusion with respect to an extracranial reference line
is much more conceivable for such people. One does not need to have in-depth awareness of cephalometrics to understand the general relationships being discussed.

If such mechanism is incorporated in the equipment itself, the true vertical line is recorded in each of the cephalogram by default. This should encourage the clinicians to shift to using more cephalometric analyses based on extracranial reference lines rather than using the traditional analyses, which were mostly formulated after the inception of cephalometric radiography.

**Conclusion**

Several studies have reported the unreliability of the occlusal plane used as a reference for WITS appraisal and suggest the use of an extracranial reference line. A greater stability and reproducibility of the HOR reference line allows its use as an extracranial reference. A higher correlation of angle ANB and “horizontal appraisal” based on linear measurements of the antero-posterior skeletal discrepancy on HOR (AH-BH) in the present study suggests the use of HOR as a more reliable reference plane compared with the occlusal plane and, therefore, WITS appraisal be replaced by “horizontal appraisal” for the day to day antero-posterior assessment of maxilla-mandible.

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