A Pragmatic Cephalometric Analysis

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Cephalometric Analysis

Downs developed the first analysis to interpret the cephalogram and to give orthodontists an instrument to plan treatment based on developed norms[1, 2]. Unfortunately, these norms came only from a limited number of adolescent Caucasians. Subsequent studies have developed more age, race and gender-specific cephalometric data for use in diagnosis and treatment planning. The most popular cephalometric analyses and treatment planning systems have been the Tweed Triangle[3, 4], Steiner Analysis[5, 6], Williams APo Line[7], and the Visualized Treatment Objectives developed by Ricketts[8] and Holdaway[9, 10].

I prefer a simple cephalometric analysis for Caucasians that measures only a few dimensions. The basis of this cephalometric analysis resides in positioning the patient in true horizontal while making the image[11-15]. This is the way we habitually view people, and any reasonable esthetic assessment must start from this natural position of the head.

Clinicians have used SNA, SNB and ANB extensively since their introduction by Downs[1, 2] and Riedel[16] to assess the sagittal difference between the maxilla and mandible, but they have more historical than practical use, since the angulation and/or length of the cranial base can cause serious misinterpretations of these measurements (Figure 1).

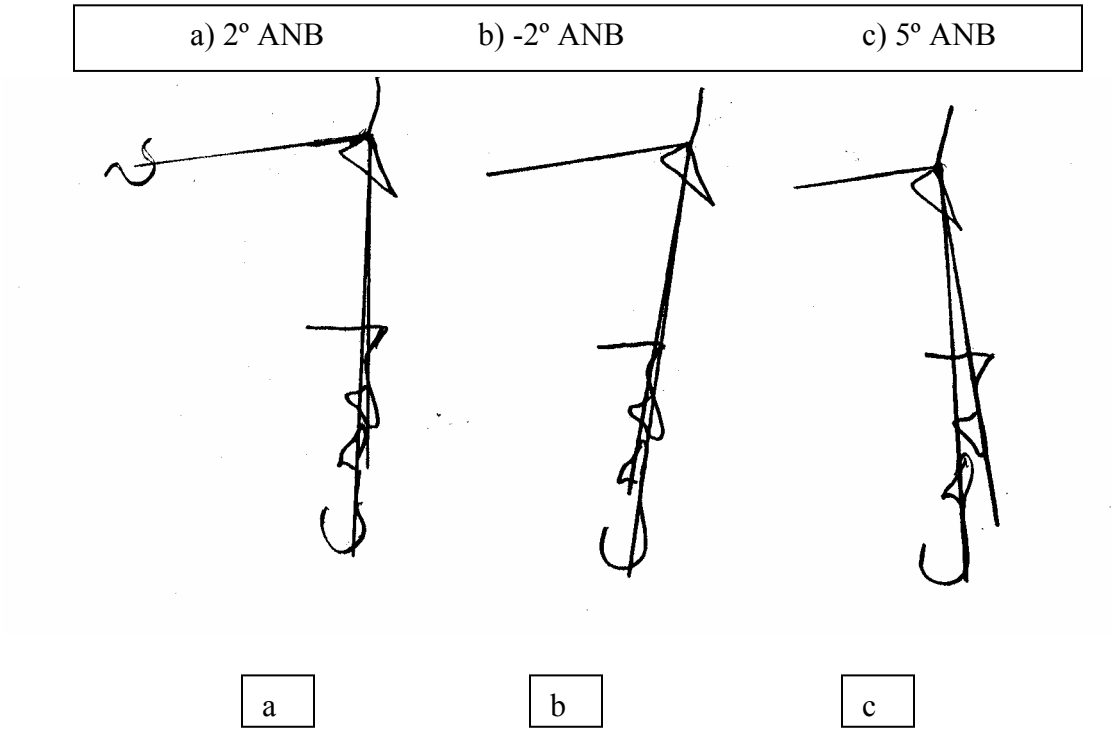

Figure 1: Effect of a) normal length cranial base, b) long base and c) short base

To assess the difference in sagittal distance between the maxilla and mandible, I prefer perpendicular lines drawn from the true horizontal to points A and B as suggested by Cooke. [14, 15] The average distance between A and B is 4mm, but the normal range has a wide variance and will extend from -1 to +10mm (Figure 2).

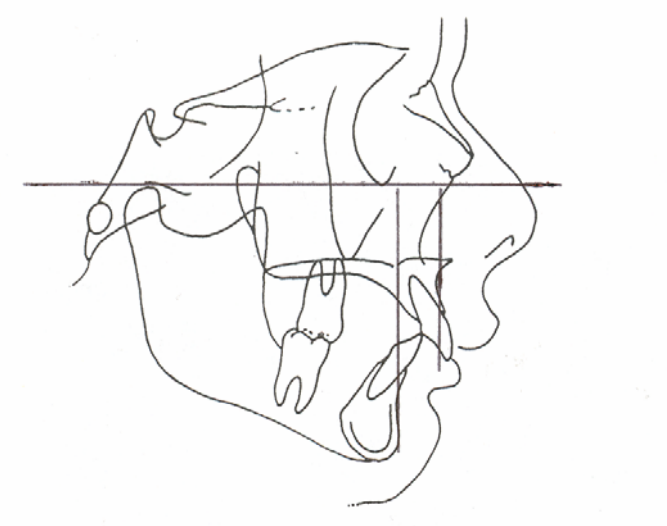

Figure 2: Measuring A – B sagittal discrepancy

I want to know the relative lengths of the maxilla and mandible as suggested by Harvold,[17] and I also want to know the anterior face height he recommended, since the forward or backward rotation of the mandible often dictates how I approach treatment. The anterior face height has more sensitivity and relevance than the mandibular plane angle and alerts us to the difficulty or ease of opening or closing the overbite of a patient

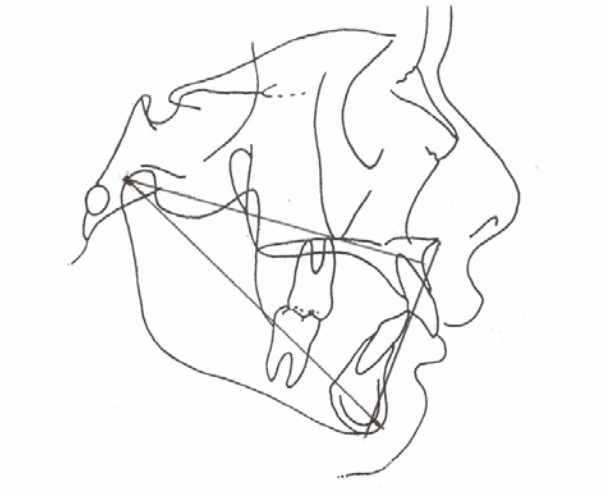

Figure 3: Maxillary and mandibular lengths and anterior face height

(Figure 3).

I like to relate the maxillary and mandibular central incisors to a line from nasion (point N) drawn through A point as suggested by Creekmore[18]. The well-positioned maxillary incisor will be 4mm ±1mm to this line and the NA line will extend through the middle of the mandibular incisor ±1mm (Figure 4).

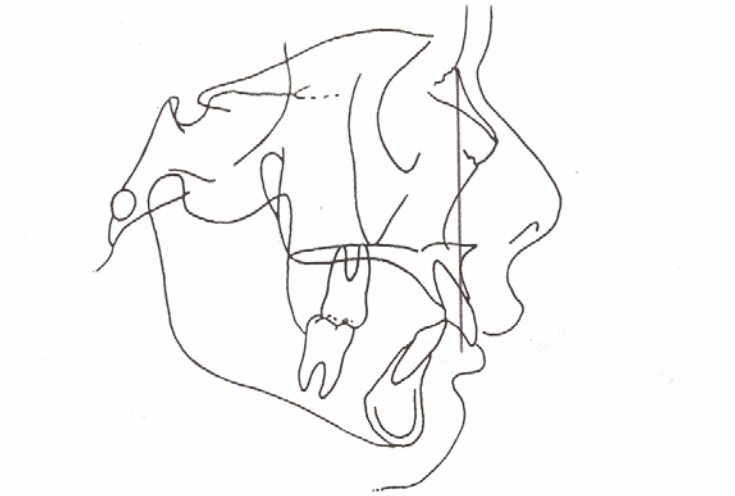

Figure 4: NA line

I also measure the maxillary incisor to the A line suggested by Alvarez[19]. The A line is a perpendicular line drawn from true horizontal through a point 1/3 of the

distance between soft tissue A point and hard tissue A point (Figure 5). A correctly positioned maxillary central incisor will lie exactly on that line ± 1mm.

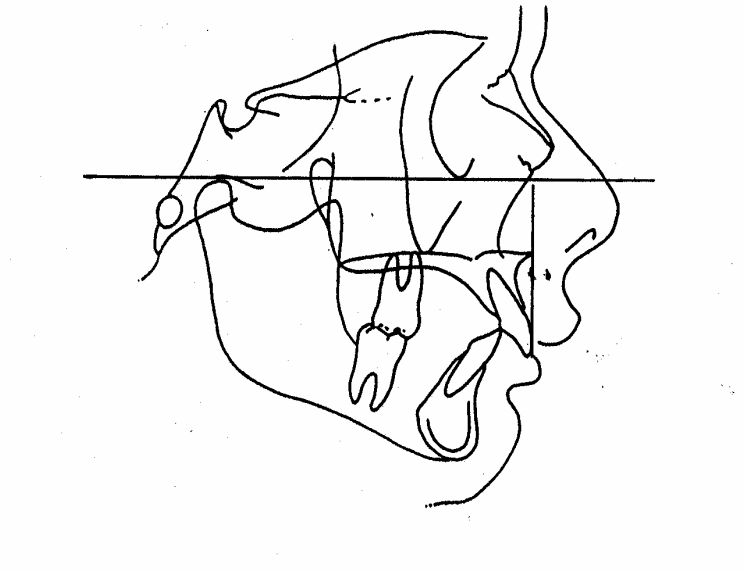

Figure 5: The A line

The most important feature of the tracing comes from an esthetic line proposed by Holdaway[9, 10], and it measures the depth of the subnasale from a perpendicular line drawn from true horizontal to the outer contour of the upper lip (Figure 6). The normal range of this measurement runs from 2mm to 4mm. When this distance measures 2mm or less, clinicians must carefully design their therapy so as not to retract the maxilla or maxillary incisors. 5mm of sulcus depth or more indicate the need to reduce the protrusion of the maxilla or maxillary incisors.

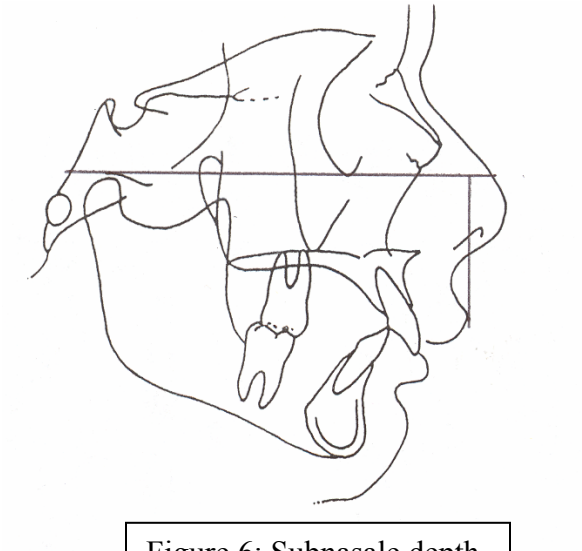

Figure 6: Subnasale depth

I want to assess the inclination of the maxillary central incisor whose axial line should run through the distal of the orbit. Finally, the occlusal plane should bisect the maxillary and mandibular molars and also the maxillary and mandibular incisors. Figure 7 displays all of the measurements used in the White analysis.

Several computer programs exist that automate the construction of cephalometric tracings, Visualized Treatment Objectives and multiple analyses. Without much doubt, these programs can save considerable amounts of time and standardize one of the mundane but necessary tasks of the orthodontic diagnosis & treatment planning after a short learning period. Table 1 contains the Harvold norms for Caucasians, while Table 2 shows the ranges of the measurements in the White analysis.

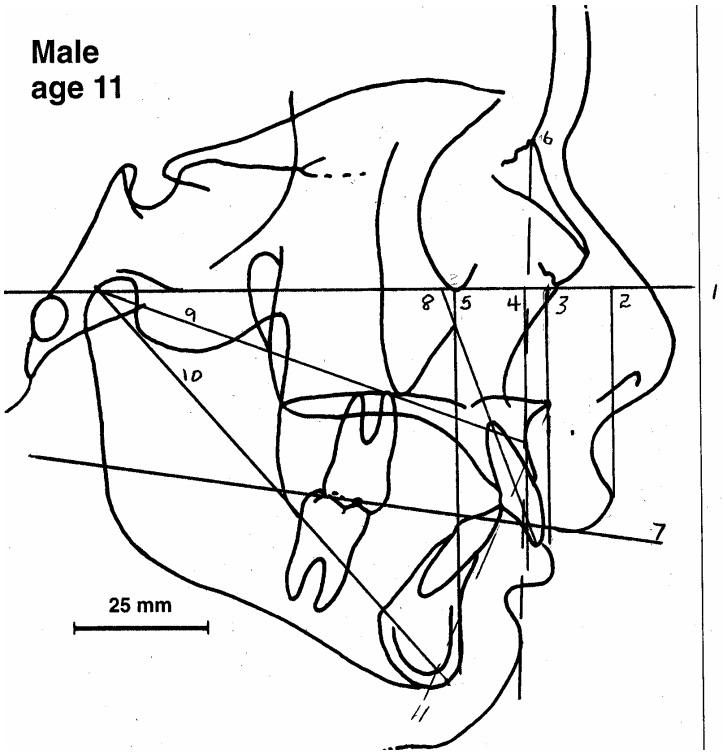

Figure 7: White's Cephalometric Measurements

White's Cephalometric Measurements

This system of cephalometric measurements depends upon taking the image with the patient in a natural head position with the eyes looking straight ahead. The head cannot be tilted up or down, otherwise the measurements will be wrong. The patient should have the lips together so that clinicians can assess the amount of lip strain and allow the accurate placement of a new occlusal plane for development of a Visualized Treatment Objective.

1. Draw a horizontal line perpendicular to the right side of the image and just beneath the orbit. This is True Horizontal.
2. Draw a line perpendicular to True Horizontal that just touches the outer contour of the upper lip and measure in millimeters from that line to the concavity of subnasale.
3. Measure the distance between soft-tissue A point to hard-tissue A point and divide that distance into thirds. Draw a line perpendicular to True Horizontal that runs through the one-third point nearest to hard-tissue A point.
4. Draw a perpendicular line from True Horizontal through hard-tissue A point.
5. Draw a perpendicular line from True Horizontal through hard-tissue B point and measure in millimeters the distance between the A and B lines.
6. Draw a line NA from nasion through hard-tissue A point and extend it down through the mandibular incisor. Measure in millimeters the distance from this line to the center of the mandibular incisor and to the facial surface of the maxillary central incisor.
7. Draw the occlusal plane so that it bisects the maxillary and mandibular molars and incisors.
8. Draw a line through the axis of the maxillary incisor and note how it relates to the orbit.
9. Measure from condylion to hard-tissue A point in millimeters.
10. Measure from condylion to hard-tissue gnathion and calculate the difference between the two.
11. Draw a line between the anterior nasal spine (ANS) and menton and measure this distance in millimeters.

Harvold's Caucasian Cephalometric Norms

	6yrs mm	7yrs mm	8yrs mm	9yrs mm	10yrs mm	11yrs mm	12yrs mm	13yrs mm	14yrs mm	15yrs mm	16yrs mm	17yrs mm	Adult mm
Females													
Mnd.Length Co-Gn	97	100	103	105	108	111	113	115	117	118	119	119	120
Mx Length Co-Pt A	80	82	84	85	87	89	90	91	92	92	93	93	93
Mx-Mnd Difference	17	18	19	20	21	22	23	24	25	26	26	26	27
ANS-Menton	57	58	59	60	61	61	62	63	64	64	65	66	67
Males													
Mnd Length Co-Gn	99	102	105	107	109	111	114	116	121	123	127	128	130
Mx Length Co-Pt A	82	84	86	87	89	91	92	93	96	97	100	100	100
Mx-Mnd Difference	17	18	19	20	20	20	22	23	25	26	27	28	30
ANS-Menton	59	60	61	62	62	63	64	65	68	69	71	71	72

Table 1: Harvold's Cephalometric Measurements for Caucasians

White's cephalometric range of values

Upper lip sulcus depth	2 – 4mm
$\underline{1}$ to A Line	0 ± 1mm
$\underline{1}$ to NA	4mm ±1mm
$\overline{1}$ to NA	0 ± 1mm
A – B difference	-3 to +10mm
Co to A	Age related (Harvold)
Co to Gn	Age related (Harvold)
ANS to Menton	Age related (Harvold)

Table 2: White's Cephalometric Range of Values for Caucasians

Cephalometric Soft-Tissue Treatment Analysis

Charles Tweed[3, 4] gave orthodontists their first cephalometrically-derived treatment planning instrument – the Tweed Triangle – which favorably placed the mandibular central incisors within the confines of the anterior alveolar cortical plates. The rest of the dentition was then arranged to fit these mandibular incisors. Tweed felt that ideally positioned mandibular central incisors had a 90º angulation ± 3º to the mandibular plane.

Practically all subsequent cephalometric treatment planning schemes drew from Tweed's idea of first positioning the mandibular central incisors and then arranging the rest of the dentition to correspond to these teeth. The Steiner Analysis[5, 6], Williams[7] APo line and Rickett's[8] Visualized Treatment Objective may have differed as to the position of the mandibular incisors, but all of them based their cephalometric treatment plans on the position of these teeth.

Holdaway[9, 10] was the first to suggest that since the maxillary central incisors determined lip posture, patients might receive better therapy if treatment planning started by determining where the lips should be at the conclusion of treatment. Rather than letting the relationship between mandibular central incisors and osseous tissue dictate the treatment plan and mechanics, Holdaway boldly suggested that clinicians should consider the effect their therapy will have on soft tissue. Ignoring this imperative can cause serious worsening of the profile and lip support as seen in (Figure 8). Few clinicians would consider the results of this therapy as beneficial for the patient's profile.

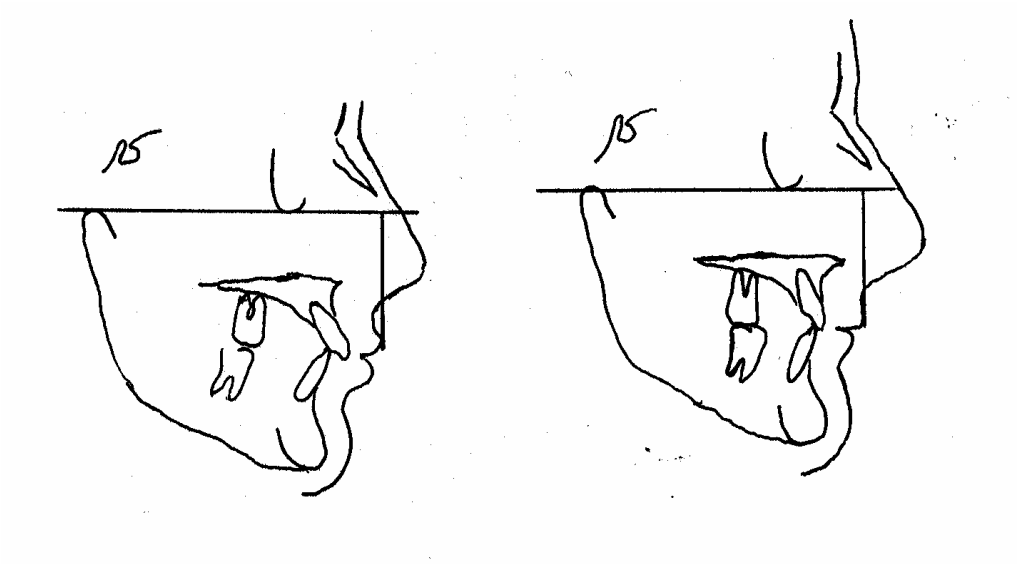

Figure 8: Result of relying on hard tissue analysis for orthodontic therapy

Perhaps Holdaway's most significant discovery was that, in Caucasians, the upper lip retracts exactly with the maxillary central incisors, with exceptions allowed for a few types of malocclusions and racial differences. Other authors have suggested differing clinical responses to maxillary incisor retraction[20, 21], but the differences are attributable to the exceptional cases Holdaway mentioned and obvious racial differences in lip thickness. Despite whatever disagreement exists about the amount of movement treatment may produce on the maxillary incisors, hardly anyone now disputes the idea that lip posture and contour are, fundamentally, a function of maxillary central incisor position. So while there may not yet be a consensus about the amount of movement expected from therapy, simple acknowledgment of this incisor function warrants attention to the exclusion of hard-tissue determinants that have no direct relationship to lip contour.

Without unanimous agreement about what to expect from treatment and subsequent positioning of the maxillary central incisors, clinicians might ask why they should rely on their placement in the face as a diagnostic and treatment planning instrument. Holdaway used this knowledge of maxillary central incisor effect on lip curl to design his visualized treatment objective (VTO), which subsequently gave him the targets for positioning the teeth. Describing the Holdaway VTO or any other is beyond the scope of this paper, but readers should familiarize themselves with his technique by reading the original articles, since all other VTO techniques have proceeded from that one.

The significant difference between Holdaway and other methods of diagnosis and treatment planning is that maxillary lip form has replaced the mandibular central incisor position as the focus of our treatment planning. When assessing the patient's

cephalometric tracing for treatment planning guidance, I synthesize a decision based on the Creekmore, Alvarez and Holdaway analyses. Much of the time these three analyses find a consensus, but when they differ substantially, I rely on the Holdaway analyses since it depends on the soft tissue exclusively, and that is what we ultimately consider when looking at someone. In Figure 9, the patient presents a disagreement among the three analyses I depend upon. The upper lip has an ideal lip sulcus of 3mm, while the maxillary and mandibular incisors are substantially advanced of the NA line, and the maxillary incisor is 1.5mm ahead of the Alvarez A line. With this patient I will use the Holdaway analysis and try not to change the position of the maxillary incisor.

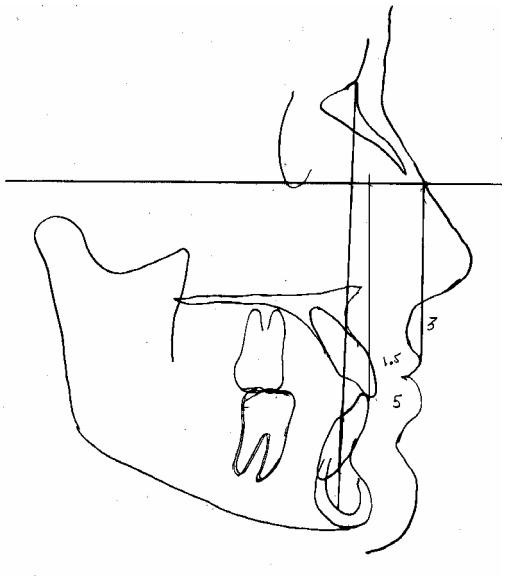

Figure 9: Disagreement among the Creekmore, Alvarez and Holdaway analyses

Perhaps the best clinical advice for clinicians who would use the maxillary incisor position for diagnosis and treatment planning is to evaluate their personal treatments and techniques to determine what they routinely accomplish with particular facial types and malocclusions. This type of private study will give clinicians a much more specific idea of what to expect with a particular treatment design and should permit orthodontists to achieve more accuracy in their treatment forecasts. Clinicians should not consider the Holdaway treatment-planning technique infallible or the only analysis necessary in deriving a diagnosis and treatment plan. However, it does place a diagnostic and therapeutic emphasis on the dental feature most responsible for lip contour and facial appearance, i.e., the maxillary central incisor.

1. Downs, W.B., *Variations in Facial Relationships: Their significance in Treatment and Prognosis.* A. J. Orthod., 1948. **34**(10): p. 812-840.
2. Downs, W.B., *Analysis of the dento-facial profile.* Am. J. Orthod., 1952. **38**: p. 162.
3. Tweed, C.H., *The diagnostic facial triangle in the control of treatment objectives.* Am. J. Orthod., 1969. **55**: p. 105-121.
4. Tweed, C.H., *The Frankfort mandibular incisor angle (FMIA) in orthodontic diagnosis, treatment planning and prognosis,.* Angle Orthod., 1954. **24**: p. 121-169.
5. Steiner, C.C., *Cephalometrics in clinical practice.* Angle Orthod., 1959. **29**: p. 8-29.
6. Steiner, C.C., *The use of cephalometrics as an aid to planning and assessing orthodontic treatment.* Am. J. Orthod., 1960. **46**: p. 721.
7. Williams, R., *The diagnostic line.* Am. J. Orthod., 1969. **55**: p. 458-476.
8. Ricketts, R.M., et al, *Bioprogressive Therapy*. Vol. 1. 1979, Denver: Rocky Mtn Orthodontics. 35-69.
9. Holdaway, R.H., *A soft tissue cephalometric analysis and its use in orthodontic treatment planning, Part I.* Am. J. Orthod., 1983. **84**(1): p. 1-28.
10. Holdaway, R.H., op. cit., *A soft tissue cephalometric analysis and its use in orthodontic treatment planning, Part II.* Am. J. Orthod., 1984. **85**(4): p. 279-293.
11. Moorees, C.F.A., Kean, M.R., *Natural head posture, a basic consideration in the interpretation of cephalometric radiographs.* Am. J. Phys. Anthropol., 1958. **16**: p. 213 -234.
12. Michiels, L.Y.F.a.T., L.P.M., *Nasion true vertical: a proposed method of testing the clinical validity of cephalometric measurements applied to a new cephalometric reference line.* Int. J. Adult Orthodontic Surg., 1990. **5**: p. 43-52.
13. Lundstrom, F.L., A., *Natural head posture as a basis for analysis.* Am. J. Orthod., 1992. **101**: p. 244-247.
14. Cooke, M.S., Wei, S.H.Y., *Nasion true vertical: a proposed method for testing the clinical validity of cephalometric measurements applied to a new cephalometric line.* Am. J. Orthod., 1988. **93**: p. 280-288.
15. Cooke, M.S., Wei, S.H.Y., *A summary five factors cephalometric analysis based on natural head posture and the true horizontal.* Am. J. Orthod., 1988. **93**: p. 213-223.
16. Riedel, R., *The Relation of Maxillary Structures to Cranium in Malocclusion and Normal Occlusion.* Angle Orthod., 1952. **22**(3): p. 142-145.
17. Harvold, E.P., *The Activator in Interceptive Orthodontics*. 1974, St. Louis: C.V. Mosby Co.
18. Creekmore, T.M., *Where teeth belong and how to get them there,.* J. Clin. Orthod., 1997. **30**(9): p. 586-608.
19. Alvarez, A., *The A Line: A New Guide for Diagnosis and Treatment Planning.* J. Clin. Orthod, 2001. **35**(9): p. 556-569.
20. Diels, R.M.e.a., *Changes in soft tissue profile of African-Americans following extraction treatment.* Angle Orthod., 1995. **65**(No. 4): p. 284-292.
21. Yogosawa, F., *Predicting soft-tissue profile changes concurrent with orthodontic treatment.* Angle Orthod., 1990. **60**: p. 199.