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Review Article

Cephalometrics for Orthognathic Surgery

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Received: November 19, 2020; **Published:** November 30, 2020

Abstract

Introduction: Cephalometry literally means the measurement and study of the proportions of the head and face. Lateral and frontal cephalometric radiographs are used to study skeletal structure relationships as well as relationships between skeletal structures and the teeth and facial soft tissues, which is difficult to do in any other way that is present. The cephalometric analysis provides the imaging of stomatognathic systems and also helps us to study the functionality of the facial patterns and their use in orthodontics and orthognathic surgery.

Aim of Work: This review aims at describing the composition of cephalometric analysis that is present and its application in orthognathic surgery.

Methodology: This review is a comprehensive research of PUBMED from the year 1970 to 2020.

Conclusion: Cephalometric analysis is an important step in preparing a patient for orthodontic treatment or orthognathic surgery. With the increasing demand for esthetic dentistry, the demand for Orthodontic rehabilitation is increasing and hence the study of cephalometric analysis provides an adjunct to clinical assessment. It is essential to have a good understanding of the landmarks used for analysis and their relation to each other. A more thorough study of the relationship of cephalometric analysis to orthognathic surgery is required in the future.

Keywords: *Cephalometric Analysis; Steiner's Analysis; Orthognathic Surgery; Mcnamara Analysis; Cephalostat*

Introduction

Cephalometry literally means the measurement and study of the proportions of the head and face. Lateral and frontal cephalometric radiographs are used to study skeletal structure relationships as well as relationships between skeletal structures and the teeth and facial soft tissues, which is difficult to do in any other way that is present. The stomatognathic system is very complex and is very difficult to image on x-ray films. Facial patterns and their functionality also play an important role in orthodontics. The cephalometric analysis provides the imaging of stomatognathic systems and helps us to study the functionality of the facial patterns and their use in orthodontics and orthognathic surgery. Even though cephalometric analysis is used for diagnosis and treatment planning in the case of orthodontic treatments or orthognathic surgery, it is not completely reliable as it is not entirely scientific. If the cephalometric analysis seems to have some discrepancies as compared to the clinical assessment of the patient, the later should always be given priority and the final decision-making factor for the treatment plan [1].

Cephalograms are basically radiographs taken with the help of a cephalostat, which helps in stabilizing the head of the patient, and later radiographic image is made for the head and cranium from a certain distance. Cephalograms are divided into two views, lateral and frontal [2]. Apart from their usage in the orthodontic treatment plan and orthognathic surgery, they are used to study the growth and development of the face and their deformities. Jaw relations in the anteroposterior plane is very important to evaluate the skeletal pattern of the patient. It is studied in all three planes, namely sagittal, vertical, and transverse, which can also be studied by cephalometrics [3].

The cephalometric analysis takes the help of various landmarks on the face and helps to measure the facial parameters. The parameters that are studied are size, position orientation, and shape. Cephalometric analysis is based on linear and angular measurements, which are compared to corresponding ones within the normal range of a particular population. The so-called normal range differs according to race, ethnic group, and gender. Different radiographic techniques may also vary the reading of the analysis; variation in technique may arise due to different head positions of patients. The analysis of cephalometric radiograph depends on the relationship of the jaw to the cranium, the relationship of jaws with each other, the relationship of teeth with each other and with the jaw and the relationship of soft tissue to various bony structures and the patient's profile [3].

Various anatomical landmarks that are used for cephalometric analysis are as follows (Figure 1).

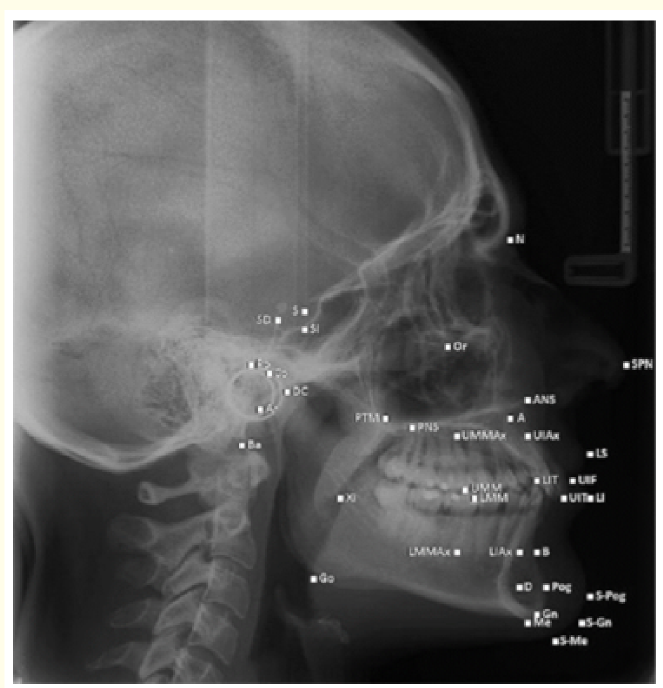

Figure 1: *Anatomical landmarks on lateral cephalogram [4].*

Anatomical landmarks

1. N = Nasion, the most anterior point of the frontonasal suture in the midsagittal plane;
2. S = Midpoint of sella (the center of sella turcica);
3. Or: Orbitale: The lowermost point in the lower margin of the bony orbit that may be felt under the skin;
4. Po: Porion is the point on the human skull located at the upper margin of each external auditory meatus;
5. Ar = Articulare, a point at the intersection of the image of the posterior margin of the ramus and the outer margin of the cranial base;
6. Go = Gonion, a point at the intersection of lines tangent to the posterior border of the ramus (articulare-superior gonion; Sup. Go) and the lower border of the mandible (menton-inferior gonion; Inf. Go);
7. Me = Menton, the most inferior point of the outline of the symphysis in the midsagittal plane;
8. Gn = Gnathion, the most anterior inferior point of the bony chin;
9. Pog = Pogonion, the most anterior point of the bony chin in the midsagittal plane;
10. B = Point B, supramentale, the deepest point on the outer contour of the mandible;
11. A = Point A, subnasale, the deepest midline point on the anterior outer contour of the maxillary alveolar process;
12. ANS = Anterior nasal spine, the most anterior point of the tip of the anterior nasal spine in the midsagittal plane;
13. PNS = Posterior nasal spine;
14. U1 = Upper incisor constructed between the incisal tip of most anterior maxillary central incisor and its apex;
15. L1 = Lower incisal constructed between the incisal tip of the most anterior mandibular central incisor.

Soft tissue landmarks

Soft tissue landmarks must be superimposed on a paper from the shadows on the radiograph. Soft tissue analysis helps in enhancing the facial esthetic of the patients [5,6].

They are as follows (Figure 2):

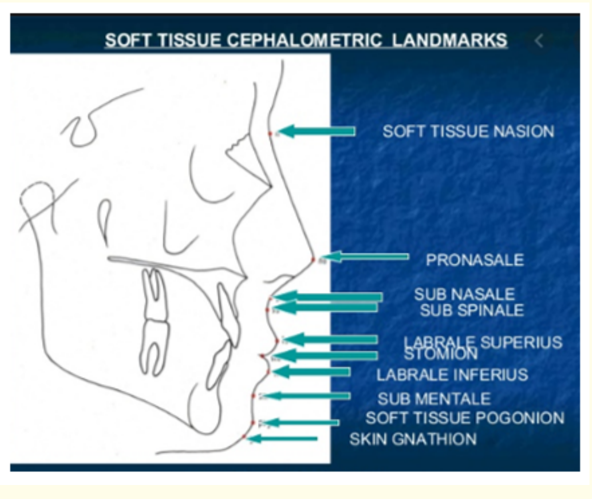

Figure 2: *Anatomical landmarks on lateral cephalogram [4].*

1. Soft tissue nasion
2. Pro nasale
3. Sub nasale
4. Sub spinale
5. Labrale superius
6. Stomion
7. Labrale inferius
8. Soft tissue pogonion
9. Skin gnathion.

A detailed cephalometric analysis often combines the following analysis and gives a comprehensive result:

1. Steiner's analysis
2. Tweeds analysis
3. Schwarts analysis
4. Burstone hard tissue analysis
5. Ricketts analysis
6. Mcnamara analysis
7. Rakosi Jarabak analysis [8].

Maxillary measurements

The various reading of cephalometric radiograph that indicates maxillary measurements:

1. The angle between S, N, A (or SNA angle)- Defines the position of the maxillary base in the anteroposterior dimension as compared to the cranial base.
2. Maxillary depth: The angle that is formed between the Frankfurt plane and line joining nasion and point A and indicates the relation of maxilla to the horizontal plane.
3. Distance between point A and McNamara line which indicates the position of the maxilla to the anterior portion of the skull
4. N-CF-A angle which denotes maxillary height.

5. The position of a to N-A - Denotes the position of the maxilla showing if its retrusive or protrusive.

6. The distance between Point V and the Distal aspect of the upper molar determines whether the extraction of the tooth pre surgically is required or not.

7. The length of maxilla is determined by the distance between PNS to ANS [9].

Mandibular measurements

1. SNB angle: Denotes the position of the mandible in the anteroposterior direction to the base of the skull anteriorly.

2. Facial angle: Angle between the Frankfurt plane and facial plane denotes if the class II or III occlusion is because of the mandible.

3. FMA angle of Tweed: Provides the vertical height of face posteriorly.

4. Gonial angle: Angle formed between the body of the mandible and posterior border of the ramus; it denotes the direction of growth of the mandible. The gonial angle increases with the age of the patient

5. Height of anterior mandible: Distance between the mesiobuccal cusp of the lower first molar to the mandibular plane, denotes the eruption of incisors.

6. The length of the mandibular ramus and mandibular body denoted by Ar-Go and Go-Pg, respectively [10].

Dental measurements

1. The angular measurement between N-A to upper incisor and the quantitative measurement (i.e. in millimeters) of N-A to incisors denotes the positioning of incisor teeth to N-A in a forward and backward direction.

2. N-B line to lower incisors denotes the positioning of Lower central incisors in forward or backward position, and the angular measurement denotes the axial inclination.

3. The angle between the plane of the mandible and long axis of incisors denotes the angle of inclination of incisors is called Incisor Mandibular Plane Angle (IMPA).

4. The angle between the long axis of the lower incisor to the Frankfurt horizontal plane is called Frankfurt Mandibular Plane Angle.

5. The procumbence of the lower incisor is determined by the angle between the A-Pog line and the long axis of lower incisors, which should be around 22 +/- 4 degrees. A-Pog line is located 1 mm behind the lower incisors [10].

Maxillomandibular relationship

The maxillary-mandibular relationship is determined by the following aspects, as mentioned in the table 1.

Parameters	Standard Value (Female)	Standard Value (Male)	Inference
Cranial base (Horizontal plane)			
Ar-Ptm (mm)	32.8	37	Posterior maxilla to mandible
Ptm-N (mm)	50.9	52	Posterior maxilla to N
Horizontal plane (Skeletal)			
N-A-Pog (angle)	2.6	3.9	Convex/concave profile
N-A (mm)	-2	0	Position of A to cranial base
N-B (mm)	-6.9	-5.3	Position of A to cranial base
N-Pog (mm)	-6.5	-4.3	Position of Pog to cranial base
Vertical (Skeletal) Vertical Plane			
N-ANS (mm)	50 SD 2.4	54	Vertical distance from cranial base to ANS
ANS-Gn (mm)	61.3 SD 3.3	68	Vertical distance from ANS to Gn
PNS-N (mm)	50.6 SD 2.2	54	Vertical distance from cranial base to PNS
MP-HP (angle)	24.2 SD 5	23	Horizontal / vertical grower
Vertical Plane (Dental)			
Maxillary incisor to NF (mm)	27.5	30.5	Upper incisor dental height
Mand. Incisor to MP (mm)	40.8	45	Lower incisor dental height
Max. molar to NF (mm)	23	26	Upper molar dental height
Mand. Molar to MP (mm)	32.1	36	Lower molar dental height
Dental			
OP to HP (angle)	7.1	6.1	Antero-posterior cant
A-B	-0.4	-1.1	Maxillomandibular relation
Maxillary incisor to NF (angle)	112.5	111	Proclination of Upper incisor
Mandibular incisor to MP (angle)	95 .9	95.9	Proclination of lower incisor

Table 1: *Maxillomandibular measurements [11].*

Soft tissue analysis

Soft tissue landmarks have to be superimposed on a paper from the shadows on the radiograph. Soft tissue analysis helps in enhancing the facial esthetic of the patients [5,6].

Soft tissue analysis is done by:

1. Steiner analysis: Used the Stella to Nasion line as the reference, which represented the anterior cranial base (Figure 3) [12].
2. Burstone analysis: Burstone analysis makes use of coordinate systems and describes the horizontal and vertical positions of the facial bones (Table 2). Coordinate systems used are:
    a. Linear measurement representing the size of bones.
    b. Angular measurement representing the shape of bones.
3. Ricketts analysis: Ricketts used a set of landmarks to assess and classify malocclusions.
4. Harvold analysis: He developed a standard for Unit Length of Maxilla and Mandible.

    Maxillary unit Length measures the distance from the posterior border of the condyle to the anterior nasal spine, and Mandibular unit length is measured from the posterior border of the condyle to the anterior point of the chin [13].

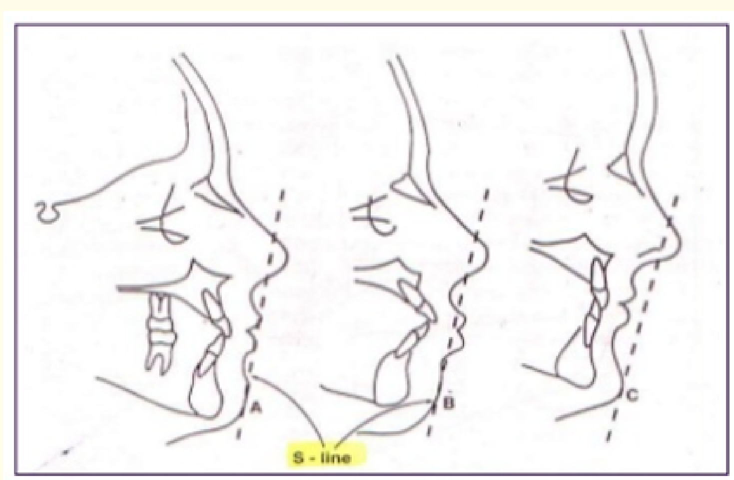

Figure 3: *Steiner analysis [12].*

In a study conducted by Brendan., *et al*. (2019), they concluded that although the concordance of Steiner analysis was higher in females, Harvold analysis was more consistent with the clinical impression of the sagittal position of maxilla and Mandible [14].

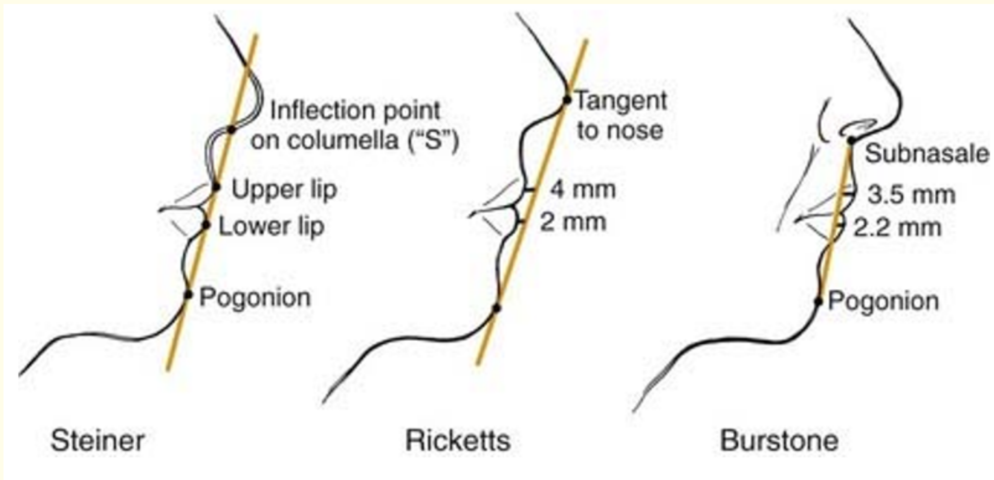

Figure 4: *Soft tissue analysis reference points for Steiner, rickets and Burstone analysis [7].*

Reference Points	Normal Range	Inference
Angle of convexity	12	Determines facial profile
The ratio of middle third to the lower third of facial soft tissues	1:1	Determines the proportion of face
Upper lip height	22+(-)2 mm	Determines the vertical height of the lower 2/3rd. of the lower third of the face.
Upper lip protrusion	3 mm	Indicates position of upper lip
Lower lip protrusion	2 mm	Indicated position of lower lip
Nasolabial angle	102	Soft tissue profile of face
Mentolabial angle	120	Indicated chin position
Mentocervical angle	100	Indicated chin position
Throat length	40 +(-) 5 mm	Used to differentiate between anteroposterior mandibular excess and maxillary hypoplasia
Vertical chin lip ratio	1 : 2	Proportion of chin and lip
Interlabial gap	2 mm	Determines lip competency
Maxillary incisor exposure	2 mm	Determines upper lip length

Table 2: *Burstone soft tissue analysis [11].*

Measurements in relation to the chin

1. Facial depth: The angle that is formed between the Frankfort Horizontal plane and facial plane. Denotes the position of the chin in a forward direction, helps in determining the skeletal nature of class II/III occlusion.

2. Middle face convexity is measured by the distance between point A to the facial plane. The average value is calculated at 9 years and comes around 2 mm and a decrease of 1 degree that is seen every 5 years in the angulation. If the convexity is high, it shows a class II relation, and in-class III patients, Negative convexity is seen.

3. Facial axis angle: It is used to determine the patient's overall facial pattern. It is formed between the Ba-N plane and Pt-Gn, and there is no change in the value with age.

4. The prominence of the chin is determined by N-Pg, and B-Pg describes the prominence related to the base of the mandible [16].

Mc Namara analysis: Mc Namara correlated the readings of:

1. Teeth to teeth
2. Teeth to jaw
3. Jaw to one another
4. Jaw to the cranial base.

The reference plane used here is the Frankfort anatomical plane and B-N line; he combines the previous approaches of Ricketts and Harvold and gives a more precise position of jaw and teeth [15]. Alam., *et al*. studied the Cephalometric norm in the Bangladeshi population and using McNamara analysis and discovered that the cephalometric norms are specific to a particular race and gender and should be studied before diagnosis and treatment planning [16].

Anteroposterior measurement

A separate completion of anteroposterior measurements is done for the maxilla, mandible, and chin. The discrepancy anteroposteriorly is also quantified using Wits Appraisal, point ANB, Ricketts Convexity at point A and Overjet. The anteroposterior position of the maxilla is determined by Maxillary Depth, Sella Nasion points A(SNA), and nasolabial angle. The mandibular position is determined by facial angle, SNB, and posterior airway space [17,18].

Conclusion

Cephalometric analysis is an important step in preparing a patient for orthodontic treatment or orthognathic surgery. With the increasing demand for esthetic dentistry, the demand for Orthodontic rehabilitation is increasing, and hence the study of cephalometric analysis provides an adjunct to clinical assessment. It is vital to have a good insight of the landmarks used for analysis and their relation to each other. A more thorough study of the relationship of cephalometric analysis to orthognathic surgery is required in the future.

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Volume 19 Issue 12 December 2020