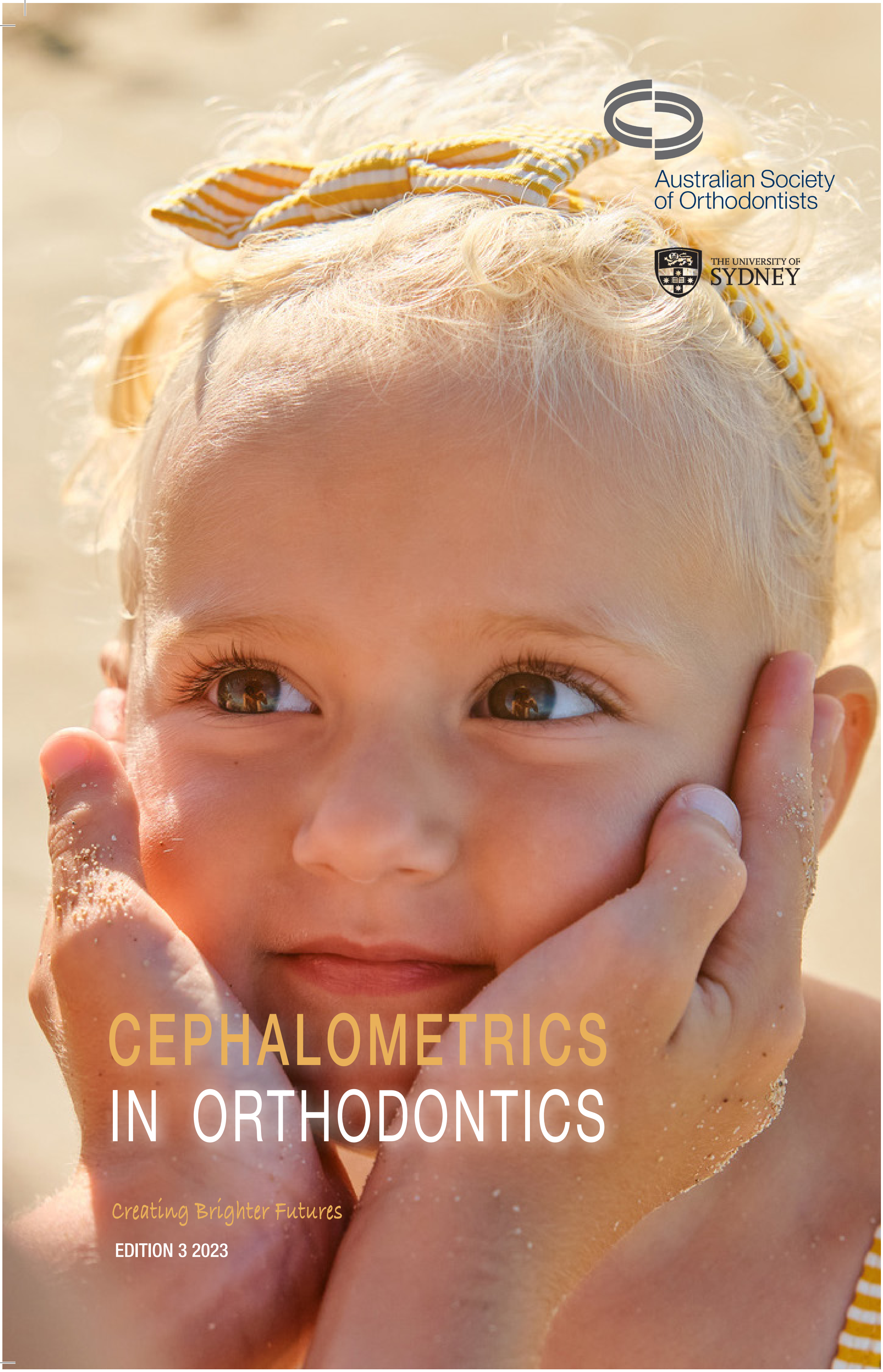


Australian Society of Orthodontists

THE UNIVERSITY OF SYDNEY

CEPHALOMETRICS IN ORTHODONTICS

Creating Brighter Futures

EDITION 3 2023

CEPHALOMETRICS IN ORTHODONTICS

Introduction

When planning orthodontic treatment, assessment of the facial skeletal and dentoalveolar relationships is essential to determine the type of treatment to be undertaken. The previous issue of Brighter Futures discussed the importance of growth assessment and timing. This issue will discuss the importance of cephalometric analysis in assessing the pattern of facial growth.

Development of Cephalometrics in Orthodontics

Cephalometrics, derived from the Greek and later Latin words for the head and to measure, is defined as the measurement and study of the proportions of the head and face, especially during growth and development.[1] The earliest craniofacial studies are credited to artists and anthropologists of the 13th to 15th centuries (including Leonardo Da Vinci, Albrecht Durer and Hendrik Spiegel). Two developments in the latter half of the 19th century, namely the invention of the first craniostat by Pierre Broca and the discovery of x-rays, made radiographic cephalometrics possible.[2]

Dr B. Holly Broadbent and colleagues developed the Western Reserve University roentgenographic craniostat in 1926. Initially the primary use of radiographic cephalometry was to study changes in normal human skeletal anatomy over time.[3] This led to the landmark Bolton-Brush Growth Study published in 1937 and the widespread use of cephalometrics for orthodontic research of the craniofacial form.[4] In the 1950's Drs William Downs, Cecil Steiner and Charles Tweed, and others, developed methods to incorporate cephalometric analyses in orthodontic treatment planning. Originally, both postero-anterior and lateral views were recommended for 3-dimensional assessment, however, very quickly it was found the lateral view was the most useful in assessing growth.

Cephalometrics was very soon regularly used for diagnosis and treatment planning as well as assessing treatment progress and for post-treatment review. The main skeletal characteristics examined were the antero-posterior (sagittal) and vertical relationships. In addition, the angulation and position of the upper and lower incisors, as well as the soft tissue profile, could be assessed. More recently cephalograms are also used for the planning of orthognathic surgery as well as cervical vertebral maturation[5] and mandibular growth rotations.[6]

Equipment and Patient Positioning

The equipment required for a lateral cephalometric radiograph includes.[7,8]

- Cephalostat: a stabilising apparatus with ear rods used to position and fix the patient's head in a standardised neutral head position
- X-ray (collimated) source: in fixed position relative to the cephalostat and film/sensor so that successive radiographs can be standardised. The x-ray tube is between 1.5 and 1.8 meters away from the midsagittal plane of the patient to minimize errors in magnification.
- Image Sensor/Cassette: contains the sensor/film and a rare earth intensifying screen placed between 45 and 55 centimeters behind the midsagittal plane of the patient to minimize errors in magnification
- Aluminium wedge filter to enhance the soft tissue visibility on the film

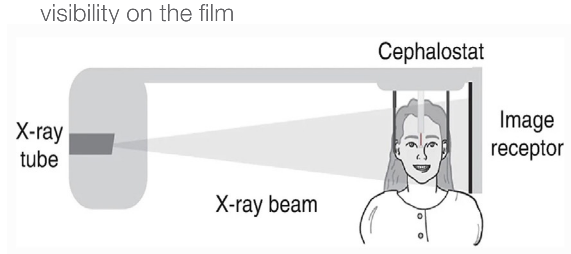


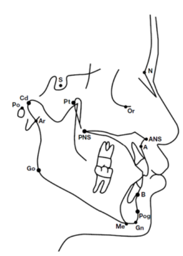
Fig 1. Diagram of the radiographic technique of obtaining a lateral cephalometric radiograph

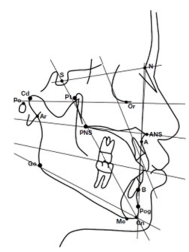
Fig 2. Cephalometric lateral radiograph demonstrating skeletal structures and the soft tissue profile. In addition the ear rods and nasal support are seen.

The patient should be positioned with the sagittal plane at right angles to the x-ray, in natural head position and in centric occlusion (or centric relation/initial contact in cases where there is a functional shift), with the lips lightly closed (unless the patient has lip incompetence).

Cephalometric Landmarks and Analyses

The common hard and soft tissue cephalometric landmarks are listed below.[9] These points can then be joined to form planes and derive angular measurements. There are numerous analyses available (Steiner, Wits, Downs and Tweed analyses are some notable examples) and often, a combination from several analyses will be used.





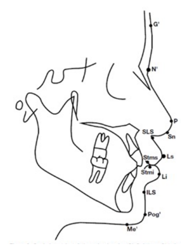


Fig 3. Cephalometric hard tissue landmarks: S – sella, N – nasion, Po – porion, Cd – condylion, Pt – pterygomaxillary fissure, Or – orbitale, Ar – articulare, PNS – posterior nasal spine, ANS – anterior nasal spine, A – A point, B – B point, Pog – pogonion, Gn – gnathion, Me – menton

Fig 4. Lines are constructed to join the landmarks for analysis of planes and angles.

Fig 5. Cephalometric soft tissue landmarks: G'- glabella, N'- soft tissue nasion, P – pronasale, Sn – subnasale, SLS – soft tissue A point, Ls – labialis superior, Stms – stomium superioris, Stmi – stomium inferioris, Li – labialis inferior, ILS – soft tissue B point, Pog' – soft tissue pogonion, Me' – soft tissue menton

Cephalometric analysis of sagittal skeletal and dental relationships

Sagittal skeletal relationships can be classified into Class I, II or III depending on the position of the maxilla and the mandible relative to the cranial base and each other eg, a skeletal Class II discrepancy may be due to a prognathic maxilla, retrognathic mandible or a combination. Similarly, a skeletal Class III discrepancy may be due to a retrognathic maxilla, prognathic mandible or combination. Dental relationships are classified as Angle molar Class I, II or III according to the position of the mesiobuccal cusp of the maxillary first molar opposing the mandibular first molar,[10] and incisal Class I, II div 1 or div 2 and III according to the position of mandibular incisor against the cingulum plateau of the maxillary incisor.[11]

The skeletal and dental relationships are not always synchronous. That is a patient with a skeletal Class III discrepancy can have a dental Class II relationship. Accurate diagnosis is essential so that the correct treatment is prescribed. For example, a growing patient with a skeletal Class II discrepancy due to a retrognathic mandible and a dental Class II div 1 relationship may benefit from a functional appliance, whereas this approach would not be suitable for a growing patient with a skeletal Class I relationship and dental Class II div 1 relationship due to for example a history of digit sucking.

Some common cephalometric assessments of sagittal skeletal relationships include:

- **Steiner analysis**[12]

Sella-nasion to A point angle (SNA): position of the maxilla to the cranial base (82°±20).

Sella-nasion to B point angle (SNB): position of the mandible to the cranial base (80°±2).

A point to B point angle (ANB): position of the maxilla and mandible to each other (2°±2).

- **Wits analysis**[13]

Distance calculated from vertical lines drawn from points A and B to the occlusal plane (AO and BO). On average, for females, AO and BO coincide and for males, AO is behind BO by 1mm.

- **McNamara analysis**[14]

Condylion to A point: effective midfacial or maxillary length.

Condylion to gnathion: effective mandibular length.

Maxillomandibular differential: difference between the length of the mandible and maxilla.

In terms of dental relationships, Angle molar classification and overjet can usually be viewed directly on the lateral cephalogram. Pre-treatment incisor angulations and positions are important in treatment planning to determine the limits of incisal movement. In patients with crowding, incisor proclination may be used to gain space. For every 1mm gain in arch perimeter there is approximately 5° of incisor proclination.[15] Although the literature is unclear as to whether proclination causes recession, in specific cases it can result in thin gingival tissues or bony dehiscences which are susceptible to inflammation or trauma.[16] Forward movement and proclination of lower incisors are side effects of both functional appliances and Class II mechanics.[17,18]

Excessive incisor proclination or retroclination beyond the neutral zone is an increased risk for relapse.[19]

Some common assessments of incisor angulations and positions include:

- **Downs analysis**[20]

Interincisal angle: angle between the long axis of the upper and lower incisors (135°±6).

Upper incisor to A point-pogonion: indicates position of upper incisors (3mm±2).

Upper incisor to sella-nasion: indicates the angulation of the upper incisors (103°±5).

- **McNamara analysis**[14]

Lower incisor to A point-pogonion: indicates position of lower incisors (1-3mm).

- **Downs and Tweed analysis**[20,21]

Incisor to mandibular plane angle: indicates the angulation of the lower incisors (90°±5).

Cephalometric analysis of vertical skeletal relationships

Vertical skeletal relationships can be classified as either high angle (vertical grower) or low angle (horizontal grower) and will require different orthodontic mechanics. Dental relationships identified with open or deep bite patterns will also require different mechanics. Knowledge of vertical relationships is also important as vertical growth is the last to be completed and continues well into adulthood, and may contribute to relapse.[22,23] Treatment planning and mechanics may need to take this into consideration. Mandibular jaw rotations are thought to contribute to a deep bite (in forward rotators) or open bite (in backward rotators) and need to be accommodated in the treatment.[6]

Some common assessments of vertical skeletal relationships include:

- **Sassouni analysis**[24]

In a vertically well-proportioned face, the four horizontal planes (sella-nasion, palatal plane, occlusal plane and mandibular plane) will intersect at a point O in the posterior cranial base.

- **Downs analysis**[20]

Sella-Nasion to mandibular plane angle: indicates the vertical growth pattern of the mandible (32°±4).

- **Tweed analysis**[21]

Frankfort to mandibular plane angle: indicates the vertical growth pattern of the mandible (25°±5).

- **Jarabak analysis**[25]

Jarabak ratio: ratio of posterior to anterior facial height (59-64%).

- **Bjork's 7 structural signs of growth rotation**[6]

The seven signs of extreme growth rotation indicating either horizontal or vertical growth include the inclination of the condylar head, curvature of the mandibular canal, shape of the lower border of the mandible, inclination of the symphysis, interincisal angle, interpremolar or intermolar angles and lower anterior face height. These are assessed from the cephalogram.

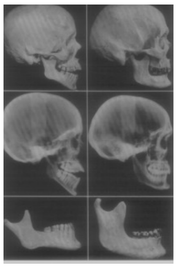
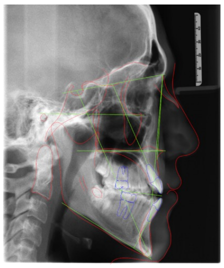
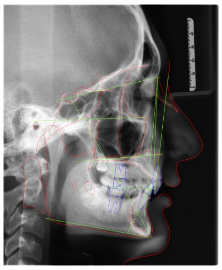




Fig 6. Structural signs of mandibular growth rotation demonstrated in two craniums-the first with basal open-bite and the second with basal deep-bite.

Fig 7. Cephalogram of a vertical (open-bite) growing patient.

Fig 8. Cephalogram of a horizontal (deep-bite) growing patient.

Cephalometric analysis of soft tissues

Traditionally, cephalometric analysis was based on hard tissues, however soft tissue analysis were developed as it became obvious that correction of the malocclusion did not always result in pleasing facial aesthetics. Soft tissue analysis of the profile, nose and lips is usually performed visually during the clinical examination. However, there are several soft tissue cephalometric analyses available, including the Holdaway, Merrifield, and Arnett and Bergman analyses, amongst others.

Some common measurements and angles for profile analysis for caucasians includes:

- **Arnett and Bergman analysis**[26]

Profile angle (soft tissue glabella-subnasale-soft tissue pogonion): indicates profile convexity or concavity (165°-175°).

Nasolabial angle: indicates position of upper lip relative to the nose (85°-105°).

- **Steiner analysis**[27]

S line (soft tissue pogonion-middle of the 'S' formed by the lower border of the nose): in a well balanced face, the lips should touch the line.

- **Ricketts analysis**[28]

E line (soft tissue pogonion-tip of the nose): Lower lip 2mm behind and upper lip and 4mm behind the E line. In young children the lips are ideally ahead of the E line while in adults they are progressively further behind the E line with age.

Limitations and inaccuracies of cephalometric analysis

There are several limitations and inaccuracies inherent in cephalometric analysis and include:

- It is a two-dimensional view of a three-dimensional object. It only provides a sagittal view and therefore transverse discrepancies or asymmetries in the frontal view cannot be analysed (this requires a postero-anterior cephalogram or a CBCT three dimensional analysis).
- Errors in patient positioning or film distance can result in distortion and magnification.
- Errors in landmark identification or tracing due to overlapping structures and poor quality radiographs or clinician variability.
- The angle ANB can be affected by both the anteroposterior position of nasion and also rotation of the jaw, while the Wits analysis cannot distinguish skeletal discrepancies caused by displacement of the dentition or specify which jaw is at fault.
- Traditional cephalometric analyses and norms were based on specific populations, mainly Caucasian populations from the early to mid 1900s. This is not applicable to other ethnic/racial populations nor does it reflect changes due to secular trends. There are now numerous studies providing cephalometric norms for various populations.

Conclusion

Cephalometric assessment is essential for diagnosing sagittal and vertical skeletal and dental relationships. There are many cephalometric analyses available, all with their own limitations and inaccuracies, so that a combination of norms from multiple analyses are often used. Rather than looking at individual measurements, assessment of the general trend of the relationships is important.

Cephalometric analysis should always be used in conjunction with other diagnostic tools, including a thorough clinical examination, extra- and intra-oral photography and study models, to formulate an accurate orthodontic diagnosis and treatment plan.

References available upon request

Past issues of Brighter Futures can be accessed at: www.aso.org.au/resources/brighter-futures-newsletters

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