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Redefining tweed's headplate correction and its implications in dental arch space requirement

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Abstract
The cephalometric appraisal of mandibular incisor teeth in relation to the mandibular basal bone had its origin in the clinical outcomes that Tweed observed in his treated cases. Although was an admirer of Angle's philosophy, failure to achieve functional and aesthetic harmony in some of the orthodontically treated cases prompted Tweed to introspect his methodology and revisit the records of his patients. Consequently, based on his clinical annotations and cephalometric aid, a Diagnostic Facial Triangle was framed to assess the severity and difficulty in treating various degrees of malocclusions in routine orthodontic practice. Furthermore, a simple and effective method in the form of Headplate/Cephalogram Correction was also developed to quantify the extent of space requirements for rectifying prognathic dentures.

Keywords: Tweed, diagnostic facial triangle, mandibular incisor teeth, incisor mandibular plane angle (IMPA), headplate/cephalogram correction

Introduction
In the evolutionary development of man, the size of the brain has increased, coupled with the reduction of the lower third of the face and the lingual tipping of the incisors on a horizontal axis, with their apex at or near the point of the rotation. Early anthropoids have shown prominent supraorbital ridges that serve as buttresses to withstand the impact of occlusion, a retreating frontal bone associated with procumbent mandibular incisors. However, in modern man, the frontal bones have become more upright, and a long forehead has developed to compensate for the disappearance of the supraorbital ridges. Likewise, the mandibular incisors have become more upright with the reduction of the alveolar bone, loss of the simian shelf, and the consequent development of the chin. All this evolutionary process is an excellent example of functional adaptation [1]. Tweed intended to establish the practical relevance of anthropometric measurement of the dentofacial region in the realm of orthodontic treatment by demonstrating the harmony between his clinical results and the scientific facts. He believed that orthodontic tooth movement can cause the failure of the treatment and arch collapse if the incisor teeth are displaced off the medullary bone area of the mandibular body. Therefore, Tweed advocated for the uprighting/lingual tipping of the incisors and reduction in tooth material by means of extraction in pursuit of better aesthetic outcomes and stable results, especially in cases where the incisor teeth were excessively proclined or where the development of the jaw itself was primarily insufficient to accommodate the full complement of teeth over medullary bone. This was in accordance with the evolutionary trends in the development of man and that forward tipping of these teeth by any orthodontic means will actually depict an evolution in the reverse direction. Since then, many clinicians have accepted the principle of "uprighting", or at least of not increasing the procumbence of the mandibular incisor teeth [2].

Mandibular incisor position and angle in relation to the lower border of the mandible
Brodie demonstrated the angular constancy of the lower border or base of the mandible when related to any fixed point by always remaining virtually the same. In other words, the nature

and pattern of growth of the mandibular body and the planes formed by the mandibular base right from the natal phase to adulthood are almost always parallel to one another [3]. Margolis was the first to relate the axial inclination of the mandibular central incisor teeth with the sagittal plane, tangent to the most dependent points on the lower border of the mandible. He named the angle formed by the interception of the long axes of the mandibular incisors with the plane formed by the lower border of the mandible, the incisor mandibular plane angle (IMPA) [4]. Furthermore, in a study of Caucasian children with normal dentitions and non-prognathous faces, he observed that 90 percent of 300 subjects examined had the mandibular incisors at right angles to the mandibular plane and therefore the incisor mandibular plane angle (IMPA) was 90 degrees, and the variation was less than 5 degrees either way [5]. Margolis emphasized the philosophy which calls for distal movement of the denture in prognathic faces to maintain its normal relationship with the rest of the head structures during orthodontic treatment and this according to him invariably depended upon the degree to which the mandibular incisors can be placed and maintained in an upright position over the medullary bone of the body of the mandible [5].

Brodie in 1940, observed the cephalometric records of 21 normal children, consisting of fourteen sets of headplates taken quarterly during the first year of life, semi-annually from 1 to 5 years of age, and annually from then on. The average for these cases was an incisor mandibular plane angle of 88.3°, therefore considered to be vertical or upright [6]. Broadbent in 1941, collected data of normal dentofacial developmental growth from the Bolton Study records of 3,500 white Cleveland children and observed the average of incisor mandibular plane angle (IMPA) to be 87.9°, which is within 0.4° of the average for the normal reported by Brodie [7]. The findings of Brodie and Broadbent were arrived at independently by them.

The tweed discourse

Dr. Tweed was unhappy with his treatment results, even after advocating the non-extraction philosophy of Angles Orthodontic treatment for more than 6 years, he was unable to achieve balance and harmony of the face in some of his patients, consequently prompting him to change his practice, rather drastically, his methods of procedure in entirety. The two factors that influenced this change were, firstly, the facial contours of some of his patients that were not improved as a result of treatment, but rather progressed to become more prognathous; and, secondly, in some other cases the teeth again became irregular, and a relapse of malocclusion was seen even after the retention period was over [1]. In 1934, Tweed undertook a retrospective analysis of his practice results. He observed that those individuals possessing balance and harmony of facial proportions and a normal occlusion, possess mandibular incisors upright over the basal bone. Tweed defined normal as, in addition, to correct occlusal relationship, must have all five of the other characteristics as outlined in the correct interpretation of Angle's definition of the line of occlusion and must possess a facial growth pattern normal in its totality. The first angle of the diagnostic facial triangle IMPA was finally established after clinical research covering a period of approximately 12 years. Moreover, he concluded that the degree of disharmony in facial contour was in direct proportion to the extent to which the denture base mesially displaced into the protrusion and that in order to attain facial aesthetics similar to those found in non-orthodontic normal patients, the mandibular incisors must be positioned at an angle of 90° or 0° with the normal range of -5° to +5°. Achieving this by over-expansion of the arches can cause impaction of both the unerupted second and third molars, thereby a major cause of relapse. Extraction was the only alternative approach. Tweed also emphasized on the importance of maintaining the integrity of the occlusal plane during the duration of orthodontic treatment, especially in patients with favorable growth trends, and considered controlled force application as the primary key for preventing any undesirable changes in the occlusal plane. The advent of cephalometry also benefited him in observing the growth process and was also alarming at the behavior of the occlusal plane during and following orthodontic treatment [8].

The diagnostic facial triangle and Headplate / Cephalogram correction

In quest of converting unfavorable cases into favorable results, Tweed introduced two more angles following his visual clinical investigations of 100 samples, the Frankfort Mandibular Plane Angle (FMA) with a mean value of 25° and consequently the Frankfort Mandibular Incisor Angle (FMIA) of 65°. Frankfort-Horizontal Plane was drawn by connecting a point $4^{1/2}$ mm above the geometric center of the ear rod with the lower border of the orbit. The mandibular plane is drawn along the lower border of the mandible and is extended posteriorly to connect with the Frankfurt plane. The third plane of the triangle is formed by extending the long axis of the mandibular central incisor to intersect the mandibular plane below and the Frankfurt plane above. This completed the diagnostic facial triangle (Figure 2). In order to arrive at an acceptable FMIA and to achieve mandibular incisor uprighting, a three-point formula was formulated by Tweed:

1. In patients with FMA greater than 30°, it will be necessary to attain FMIA of 65°.
2. In patients with FMA ranging between 20° and 30°, an average of 68° FMIA is acceptable.
3. In patients with FMA below 20°, an effort should be made not to exceed an IMPA greater than 94° [8, 18].

Tweed's Headplate Correction/Discrepancy is a clinical method of calculating the amount of space that is required for the uprighting/lingual tipping of the mandibular incisors in addition to the tooth material-arch length deficit. Earlier in the Tweed era, this was done by drawing the diagnostic facial triangle directly on the Headplate/X-ray radiographic film with white ink. However, for more than the past 4 decades, this procedure has been carried out on the roentgenographic cephalometric tracing sheets, hence the alternate name, Cephalogram Correction [9].

Steps to arbitrarily measure Headplate/Cephalogram correction (Method 1)

1. Draw the diagnostic facial triangle as per the actually observed angles for the patient's FMA, FMIA and IMPA.
2. Draw a dotted line upward starting from the apex of the mandibular incisor to intersect the FM plane at the desired/acceptable angle of FMIA and/or IMPA in accordance with the Tweeds three-point rationale.
3. This dotted line indicates the desired axial inclination of the mandibular incisor teeth.
4. The distance between the solid line (actual inclination of mandibular incisor) and the dotted line (desired/projected incisal inclination) is measured in millimeters along the occlusal plane of incisal edges (Figure 2) and multiplied

by "2" (considering both sides of the dental arch), representing the amount of lingual tipping (headplate correction) necessary to satisfy the proposed FMIA [8, 9, 10].

This measurement obtained is combined with arch length discrepancy to calculate the total discrepancy in millimeters.

Steps to precisely measure Headplate/Cephalogram Correction (Method 2)

According to tweed, 12° of lingual inclination yields 5 mm of space, or 1° = 0.8 mm approximately, for both sides of the arch [11]. However, considering that a controlled crown tipping of mandibular incisor tooth with negligible root apex displacement is produced along an arc, the exact amount of space (mm) obtained per degree of inclination change (°) can be precisely calculated by following these steps:

1. Repeat steps 1, 2 and 3 as described above.
2. Use the Divider with a pencil holder. Place the metal pointed tip of the divider at the apex of the mandibular incisor tooth and extended the divider along its long axis, such that the pencil tip touches the incisal edge of the mandibular incisor over the solid axial inclination line.
3. Draw an arc, extending from the solid line (actual incisal inclination) up to the dotted line (desired incisal inclination). The circumference of the arc represents the line of lingual tipping. (Figure 3)
4. Use the mathematical formula: $S = 2\pi r\left[\frac{\theta}{360}\right]$, where S denotes arch length (cm), **r** is the radius (axial length from apex to the incisal edge in cm), θ is the angle formed between actual and proposed IMPA axial lines.
5. Multiply it by "2" (considering both sides of the dental arch) and dividing by "10" (converting cm into mm). Therefore, the actual amount (mm) per degree change (°) in the inclination of mandibular incisor teeth (headplate correction) is obtained.

Significance of Headplate/Cephalogram Correction

1. To determine the severity of malocclusion in mixed dentition cases and perhaps undertake preventive and interceptive treatment protocols such as serial extraction.
2. To determine the difficulty in treating the malocclusion and therefore employ the favorable treatment mechanics at the onset of fixed mechanotherapy.
3. To evaluate the extraction/non-extraction fate of the permanent dentition [11].

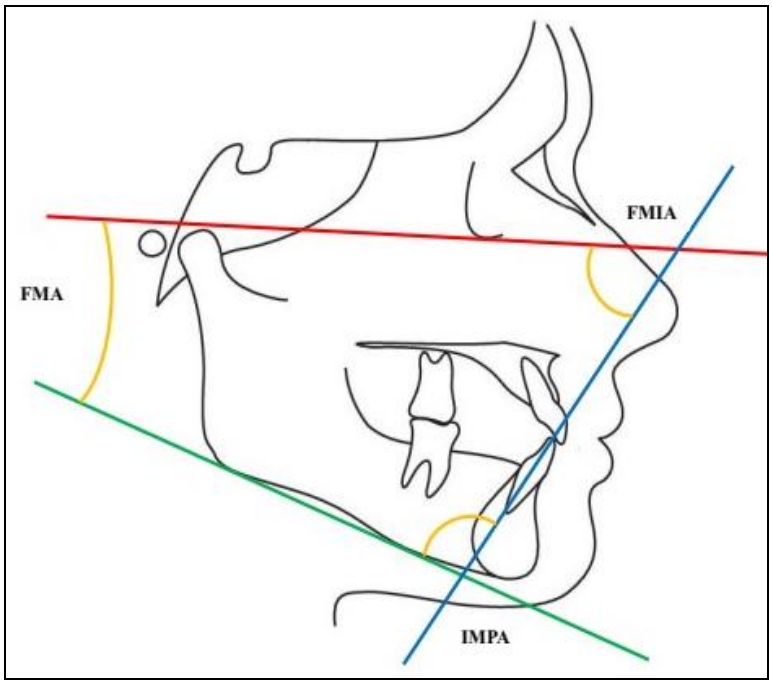

Fig 1: Tweed's Diagnostic Facial Triangle

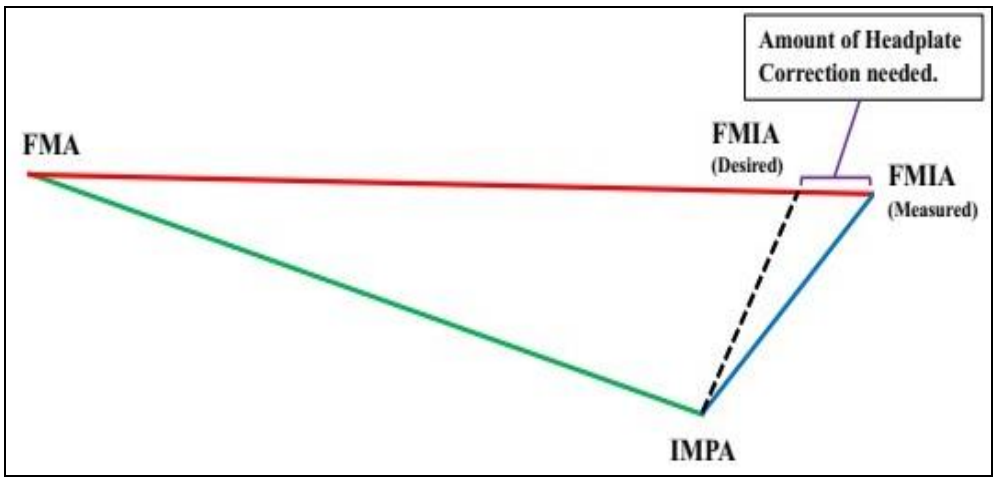

Fig 2: Tweed's Headplate Correction-Method 1

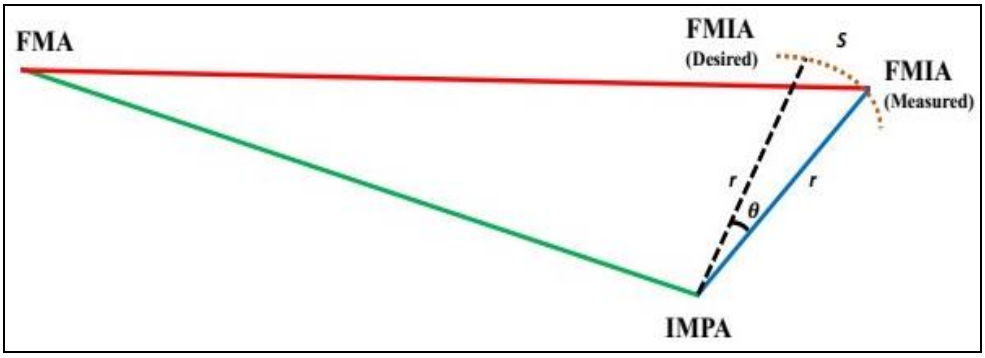

Fig 3: Tweed's Headplate Correction-Method 2

Conclusion

Determination of the lower incisor position and IMPA value is crucial for orthodontic treatment planning. In Class II subjects, with a proclined lower incisor, the apex lies near the lingual cortex, whereas In Class III subjects, with a retroclined lower incisor, the apex approaches the buccal cortex [12]. Several investigators have reported and signified the importance of the ideal positioning of the mandibular incisors in relation to the basal cancellous bone [13]. Ciavarella et al. [14] evaluated the relationship between the changes in lower incisor position following orthodontic treatment with the development and progression of gingival recession. It was observed that the patients with excessively proclined lower incisors (IMPA > 95°) at the end of orthodontic treatment apparently developed gingival recession in contrast to those subjects who had incisor inclination within the normal range. Mills [15] recommends the undisturbed position of the lower incisors as the most stable position since all the peri-oral forces have harmonized with the incisor position. It is noteworthy to mention that Tweed's diagnostic facial triangle norms should only be used as a guide and not as an absolute benchmark for all diverse racial or ethnic groups. Hence, using specific norms for specific races or ethnic groups will help us in achieving more accurate diagnosis and treatment planning [13, 16, 17, 19].

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