

COMPARATIVE ANALYSIS OF THE USE OF ANB ANGLE AND WITS APPRAISAL FOR DETERMINATION OF THE SAGGITAL JAW RELATIONSHIP

КОМПАРАТИВНА АНАЛИЗА НА УПОТРЕБАТА НА ANB АГОЛОТ И WITS АНАЛИЗАТА ЗА ОДРЕДУВАЊЕ НА САГИТАЛНИТЕ МЕЃУВИЛИЧНИ СООДНОСИ

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Abstract

Introduction: Finding a simpler and more accurate approach for the analysis of sagittal relations of jaws is a big challenge. The choice is not simple, due to the variability of the points on which the ANB angle is based, which leads to the usage of an additional linear parameter such as Wits. **Objective:** To observe the daily involvement of the Wits appraisal and its correlation with the ANB angle, as well as to show the justification of the usage of the Wits appraisal, its stability, and modifications for obtaining a comprehensive diagnostic image. **Material and methods:** Literature reviews and analysis were performed by the research network ResearchGate, Academia.edu and PubMed, by searching for papers not older than 2000, with the keywords Wits appraisal, Steiner cephalometric analysis, Orthodontic cephalometry and literature from books and contemporary journals publication. **Results:** The variable position of the points that determine the ANB angle showed the justification for the additional use of the Wits appraisal, and a correlation was observed in normodivergent patients. The influence of the occlusal plane position on the Wits noted its disadvantage and its modification requirement in patients with increased lower face height and high FMA angle. **Conclusion:** Sagittal jaws relations analysis should take into consideration additional factors such as the size of the FMA angle, the inclination of the occlusal and the mandibular plane, the vertical growth. If necessary, the modification of the Wits appraisal can be used. **Keywords:** Wits appraisal, Steiner cephalometric analysis, orthodontic cephalometric analysis.

Апстракт

Вовед: Пронаоѓањето на поедноставен и попрецизен пристап за анализа на сагиталните вилични соодноси претставува голем предизвик. Изборот не е едноставен, поради променливоста на точките врз коишто се темели ANB аголот, што довело до употреба на дополнителен линеарен параметар како што е анализата според Wits. **Цел:** Да се воочи секојдневното вклучување на Wits процената за анализа на сагиталните меѓувилнични односи и корелацијата со ANB аголот. Истовремено да се прикаже оправданоста на употребата на Wits процената, нејзината стабилност и модификации на истата за добивање на сеопфатна дијагностичка слика. **Материјал и методи:** Беше извршен преглед и анализа на литература од академската мрежа ResearchGate и Academia.edu и од PubMed, преку пребарување трудови не постари од 2000 година, со клучните зборови Wits appraisal, Steiner cephalometric analysis, Orthodontic cephalometry и литература од книги и трудови со најнови сознанија на испитуваната тема. **Резултати:** Променливата положба на точките кои го одредуваат ANB аголот ја прикажа оправданоста на дополнителната употреба на Wits анализата, а корелација е забележана кај нормодивергентни пациенти. Влијанието на положбата на оклузалната рамнина врз Wits анализата го нотираше недостатокот на оваа анализа, а со тоа ја нагласува потребата за нејзина модификација кај пациентите со зголемена долна лицева висина и висок FMA агол. **Заклучок:** При сагитална анализа на меѓувилничните односи треба да се земат во предвид и дополнителните фактори како што се големината на FMA аголот, инклинацијата на оклузалната и на мандибуларната рамнина, вертикалниот раст. Доколку е потребно дополнително може да се примени и модификацијата на Wits анализата. **Клучни зборови:** Wits процена, Steiner кефалометриска анализа, ортодонтска кефалометриска анализа.

Introduction

The analysis of cephalometric images plays an important role in orthodontic diagnosis and in the analysis and monitoring of treatment as well. Recognizing the importance of cephalometry, dates back to 1931 when

the cephalometer was first introduced by Broadbent in the United States¹ and Hofrath in Germany². X-ray cephalometric analysis allows monitoring of changes related to growth, diagnosis, and classification of malocclusions through a number of developed analysis techniques². In addition to the analysis of sagittal relation-

ships, cephalometric images can also be used to analyze facial symmetry. The manner of recording the patient is determined depending on whether analysis of the sagittal or frontal ratios will be performed, i.e., the position of the head in the cephalostat. Profile analysis recordings are more widely used³. The large number of available cephalometric analyses use different anatomical and constructed points that are drawn on paper on the cephalogram if the standard analysis technique is used, which then results in a number of different reference planes, lines and angles. Hence the numerous techniques for orthodontic treatment analysis and planning⁴, Cavdar et al.⁵ point out the weakness of the standard technique in two aspects: the longer time required for analysis, and the possibility of errors in drawing points and lines. On the other hand, no differences were observed in the analysis, according to Steiner, with the conventional method in relation to the computer method with CephNinja⁶. In 1948, Down developed a method for analyzing cephalometric images based on a study of 20 individuals with excellent occlusion, and over the years it has been proven that the recommended standard values are almost constant, despite the numerous variations in the study. As in all spheres, orthodontics still strives for a technique that will meet the requirements for a good analysis, and at the same time, is simple to use. This led to the development of the Steiner analysis in 1953, where the SN plane is the reference plane (as opposed to the Frankfurt reference plane of the Down technique)⁷. Steiner, in his method recommended an evaluation of the analysis of skeletal, dental, and soft tissues. Skeletal analysis shows the relationship of the upper and lower jaw to the base of the cranium, but also the relationship of the jaws to each other. Dental analysis includes the relationships of the upper and lower incisors respectively to the jaw in which they are located, but also their relationship to each other. Soft tissue analysis plays a role in contributing to the balance and harmony of the lower facial profile⁸. In order to determine the skeletal sagittal relationship, he used the angles SNA to determine the relation of the upper jaw to the cranial base, and SNB angle for the relation of the lower jaw to the base⁹. In 1953, Riedel introduced the ANB angle for the relationship between the two jaws, which Steiner accepted and popularized later in his analysis as an excellent indicator¹⁰. The average value for the SNA angle is 82 degrees; higher values of this angle indicate prognathism of the maxilla to the cranial base, and lower values of the same indicate retrognathism of the maxilla relative to the cranial base. The average value for the SNB angle was defined by 80 degrees, and a higher or lower value of this angle would mean consequent mandibular prognathism or retrognathism of the mandible relative to the

cranial base. While SNA and SNB have precisely defined mean values, it has been accepted by many authors^{5,6,9,10} that the ANB angle is in the range of 2 to 4 degrees. A value between 2 and 4 degrees indicates Class I of skeletal intermaxillary relation, a lower grade means Class III, and a larger grade Class II⁴. But in addition to the sagittal relationship, Steiner in his analysis also gave guidelines for analyzing the vertical relation by determining the angle between the occlusal plane and the SN line = 14 degrees; larger angle indicates vertical growth and skeletal open bite, while smaller angle indicates horizontal growth and deep bite. For dental relations, he recommended measuring the distance and angle of the most labial point of the incisors to the NA line for the upper and to the NB line for the lower incisors, as well as the interincisal angle, and additionally introduced the Holdaway ratio = 4mm. As a base for the position of the lips, he presented the S' line, which determines protrusion or retrusion if the lips are in front of or behind the line itself⁹.

However, studies have shown that Steiner angular measurements are quite sensitive, especially for the ANB angle which depends on the position of the nasion point (N) and sella turcica (S), the length of the anterior cranial base, and the type of vertical growth. To overcome these sensitivities, Jacobson A.¹¹ proposed, as an addition, the Wits appraisal where the occlusal plane passing through the cusps of the first premolars and molars is taken as the reference plane. Regarding the overlap and / or the existence of the distance between the normal AO and BO lowered from points A and B for each jaw respectively in the occlusal plane, additional information is obtained for defining the sagittal jaw relationship¹⁰.

Aim

The aim of this paper is to observe the daily increasing involvement of the Wits appraisal in Steiner analysis of cephalometric images, due to the variability of points used in Steiner analysis, the correlation between the ANB angle, and the Wits appraisal. At the same time to present the need as well as the validation for including the Wits appraisal in the Steiner analysis, but also the stability and modulations of the eponymous estimation.

Material and methods

In order to achieve the set goal, a review of literature available on the academic network ResearchGate, Academia.edu and the medical network PubMed was performed. The PubMed search included the following keywords: Wits appraisal, Steiner cephalometric analysis, Orthodontic cephalometry. Searching for literature with the abovementioned keywords was limited by the time

frame of papers published from 2000 to the present. An additional filter was a search for complete free texts, but also abstracts. The papers presented as abstracts were then taken from the original journal where they were published in full. The search by the above filters generated a multitude of papers, of which 13 papers were used as a literature review for this paper.

In addition to searching these three networks, 6 papers published in scientifically accredited journals (listed in the references) were used due to the intrigue of the content of the papers themselves.

For the aforementioned purpose, a review of literature from the books with relevant themes and from novel paper facts was included.

Results and discussion

The modern and fast-paced way of life imposes a search for better methods for more successful diagnosis and treatment, which has led to the inclusion of the Wits appraisal in the Steiner analysis. However, a large part of the scientific community in their research seeks to find the correlation between the ANB angle and the Wits appraisal, in order to justify the additional use of this method which prolongs the analysis. The study by Ahmed M. et al.¹⁰ showed a significant positive correlation between the Wits analysis and the ANB angle ($r = 0.831$). They further state that hyperdivergent or hypodivergent vertical growth affects sagittal relationships, as well as the accuracy of determining a relevant anteroposterior parameter. Therefore, they emphasize that determining the ANB angle as the most relevant parameter in their study refers to normodivergent patients, and that this should be taken into consideration in everyday practice. By stating that the study refers to normodivergent patients, the authors distance themselves from the relevance of ANB as a stand-alone parameter for other groups of patients.

Correlation testing is also reported in the study by Jan A. et al.¹², which again confirmed a significant correlation between the ANB angle and the Wits appraisal in determining sagittal jaw relationship ($r = 0.469$). Knowing the weakness of the ANB angle, however, they state that other studies require a connection between the ANB angle and the SN line, which actually leads to a prediction of the Wits appraisal. In addition, this study did not take into account the effects of the position of the palatal plane, the occlusal plane, and the horizontal overlap of the incisors. According to the above, relying only on the ANB angle and neglecting other parameters can lead to incompletely accurate diagnosis.

Furthermore, Jacobson A.¹¹ points out the instability of the ANB angle for two reasons: the variation of the anteroposterior relation of the point nasion (N) to the

jaws, and the rotation of the jaws towards the cranial reference plane (SN plane). According to Wits' findings, individuals had severe malocclusion and moderate malocclusion, but according to the ANB angle, all individuals would be characterized with the same degree of malocclusion. Thus, Jacobson A.¹¹, in his study, confirms the need to supplement the analysis with the Wits appraisal to obtain a more comprehensive and more detailed picture not only of the type but also of the severity of the anomaly, which significantly affects the overall treatment that would be undertaken, and its outcome, i.e., that the diagnosis is one of the guiding factors for success.

In addition to Jacobson A.'s¹¹ assertions of ANB angle deficiency, due to the position of the point (N) and the rotation of the jaws towards the SN line, it also depends on the vertical dimensions, especially on the anterior vertical dimension. Furthermore, the mean values refer more to dolichocephaly, than to brachiocephalic or mesocephalic individuals. However, with the Wits appraisal, the vertical dimension also has a large effect, as does the position of the occlusal plane¹³.

The examination of the connection between these two methods goes so far that some of the authors analyze it through computed tomography, making it clear that both parameters coincide only in patients with Class III malocclusion. Hence, the question of the influence of the position of the occlusal plane and the Wits appraisal arises again, and the position of the mandibular plane that showed a correlation with the Wits estimate ($r = 0.242$) must not be neglected. The previously obtained findings are in favor for the use of both parameters for the analysis of sagittal relationships, but without neglecting the other factors that affect them¹⁴.

To make the picture more complete, Jabbar A. et al.¹⁵ analyzed the relationship between ANB angle, Wits appraisal, and horizontal overlap in individuals with Class I malocclusion, with Class II division 1 malocclusion and Class III malocclusion. There was a strong statistical correlation between the ANB angle and the horizontal overlap only in individuals with Class III malocclusion, and the same significance was observed only in individuals with Class III in analysis with the Wits appraisal. Hence, new views are opened which indicate that, in addition to these two analyses, the horizontal overlap can also be a good indicator of sagittal skeletal Class III malocclusion, but certainly not the only and pathognomonic indicator.

Another factor to consider when analyzing these two parameters is their comparison in different populations and genders. This is shown in the retrospective study of Duran SG. et al.¹⁶ of the Turkish population. The inconsistency between the two parameters was considered for each gender separately. Again, the conclusion is that both parameters should be used together and simultaneously,

but also that the shortcomings of the ANB cannot be corrected only with the use of Wits appraisal because it is once again confirmed that Wits has its drawbacks, especially dependent on dental points, as well as from the vertical growth of the alveolar ridge. Furthermore, there is a difference between these two parameters and their correlation between the different genders. It is again proved that the position of the mandibular and occlusal planes affects the inconsistency between these two parameters. Increasing the SN-MP angle leads to a greater discrepancy towards these two parameters. Additionally, the ANB angle can 'overestimate' the sagittal relations of the jaws as the occlusal plane increases, while the Wits can give lower values at the same occlusal plane increase, hence the discrepancy between these two parameters occurs as a result of changing the position of the occlusal plane.

In addition to comparing these two parameters, the scientific community also compared only the Wits parameter in different ethnic groups, showing that the Wits appraisal is ethnically specific and once again proved to be gender-dependent as in the previous study¹⁷.

There is no doubt that the examinations have deepened and even go so far as to compare the two parameters with dental parameters such as the position of the molars and its impact on them. In the study of Aldrees AM. et al.¹⁸ the correlation between the dental relation of the molars and the ANB angle was 57.7%, while in the study of Zhou L. et al.¹⁹ the correlation was 61%. The difference is explained with the age of the patients who were included in both studies, i.e., the presence of patients with early permanent dentition where the molars are still in the tubertuber position before their transition to Class I. However, the coherence of the ANB angle and Angle molar classification is greater in Class I dental malocclusions than in other dental classes of malocclusions. While the Wits appraisal showed a greater correlation with Class III dental malocclusions, which is thought to be due to the increased mandibular angle that affects the position of the lower first molars. The dependence of both parameters on other factors arises again.

Iwasaki H. et al.²⁰, gave special attention to the correlation of these two parameters in Class III malocclusion. The anteroposterior relationship between the upper and lower dental arch during adolescence is quite susceptible to change, therefore it is important to determine the anteroposterior relationship of the jaws for a proper and accurate diagnosis. Of course, they recommend using the ANB angle or the Wits appraisal for this purpose, but they stated that given the results it is difficult to evaluate which parameter would be more relevant. Therefore, the motive was to examine the differences in the assessment of jaw relationships with the two parameters and to make a recommendation for their combined synergetic use.

The analysis confirmed that using the ANB angle, the jaw discrepancy is more severe or more pronounced than the same jaw relationship to be analyzed with the Wits appraisal in patients with Class III dental malocclusion.

Furthermore, they concluded that in case of greater retro inclination of the incisors and a larger negative horizontal overlap, the ANB angle is more relevant for assessing anteroposterior jaw relation than Wits appraisal. Due to the fact that the rotation of the jaws affects the values of the ANB angle, the inclination of the mandibular plane was analyzed as well and was stated that the mandibular plane is not a geometric factor that affects the "overestimation" of the value of the ANB angle.

According to the results obtained from the study, it can be noticed that in patients with a large horizontal negative overlap, flat occlusal plane, and rotation of the mandible counterclockwise, the use of the ANB angle to assess the anteroposterior relationship of the jaws is justified.

Interest in the influence of occlusal plane inclination on ANB angle values and the Wits appraisal to assessing the anteroposterior jaw relationship, was also shown in the Santo DM study²¹. He estimated that the angular measurements are geometrically quite sensitive and cannot show completely accurate results, in addition, that they are dependent on the age of the patients. Due to these deficiencies of the angular measurements, and cited in previous studies, Santo DM²¹ also confirms the complementary use of Wits appraisal as a linear measurement to partially eliminate the shortcomings of the angular measurements, but at the same time taking into account that linear measurements are dependent on other factors, including the position of the occlusal plane. Although the ANB angle and the Wits appraisal evaluate skeletal anomalies in the same direction — anteroposterior, they would be expected to coincide to a large extent, but this is not always the case. In this study, it was challenging to show what other parameters may be a key factor for their mismatch. Santo DM²¹ thought that this could be as a result of the variation in the position of the occlusal plane as well as the facial height. According to the analysis, some of the patients had a high occlusal plane, and some a low position of the same plane.

In patients with low occlusal plane (almost straight occlusal plane) consistency was observed, i.e., almost equal classification of the severity of sagittal malocclusion, but in contrast, in highly placed occlusal plane (inclined cranial), difference, in the classification of the severity of sagittal malocclusion between the ANB angle and the Wits appraisal, was confirmed in the majority of patients except one. The analyses in this study confirm the fact that the inevitable use of both parameters in the analysis of the sagittal jaw relationship, but without excluding other factors from the analysis that affect the parameters

themselves, and can lead to crucial errors from the start of the treatment plan and diagnosis of malocclusion. Equally important is the influence of the dental parameters that actually define the occlusal plane, not just the point nasion (N).

The findings suggest that the Wits appraisal has also disadvantages and therefore cannot fully cover the imperfections of the ANB angle for sagittal jaw analysis. Therefore Hayes L. et al.²² proposed a modification of this appraisal for patients with a high FMA angle or with increased lower anterior face height.

In a perfect world, the use of sagittal relationship analysis only by defining the values of the ANB angle, and only the Wits appraisal without modifying it, would be sufficient. However, as the variations between the units become higher, these two basic parameters cannot be a fixed relevance for defining the sagittal jaw relations.

In accordance with this, Hayes L et al.²² concluded that the value of the ANB angle cannot be used on its own to diagnose the type and severity of the anomaly. Namely, the ANB angle was the same for both patients, while the values of the Wits appraisal were quite different for the two patients in the same group. They noted that Wits appraisal depends on the position of the occlusal plane, which could affect patients with a high FMA angle and an increased lower face height. They therefore proposed a modification of this appraisal by forming the so-called newly constructed "normal" occlusal plane, i.e., an angle between the "normal" occlusal and mandibular plane NOP-MP of 17 degrees. This would actually mean replacing the present acute angle in certain situations. The advantages of this method are in the evaluation of patients with high FMA angle and increased lower face height, where the ANB angle and the classic Wits appraisal are not the most relevant for analysis in these patients. Another advantage of this modification is that it can predict unwanted vertical skeletal growth on the anterior part of the mandible. In addition, this proposed modification of the Wits appraisal makes it possible to predict the construction of the occlusal plane in patients with an anterior open bite. However, it should also be noted that this modification is only an addition to the use of the other two parameters and does not mean their exclusion from the analysis. On the contrary, he adds that in the presence of normal values of the FMA angle, and when the analysis of the angles SNA and SNB are within the normal standard values, the analysis with both the ANB angle and the conventional Wits appraisal and the modified Wits appraisal is equally valid for defining anteroposterior relations of the jaws. All this again emphasizes the fact that many factors affect the values of these two parameters and that if there are factors such as high FMA angle and increased lower face height, the supplementary use of the modified

method with the other two previous parameters gives a more realistic picture of the jaw position²².

According to the abovementioned analyses, with the covered advantages and disadvantages of the parameters for analysis of the sagittal jaw relations, the question arises why not look further, why use only these two parameters and their modification, and not introduce a completely new method that might provide even better and more relevant values for diagnosis²³.

Therefore, Nagar et al.²³ in their study propose a completely new method for sagittal analysis of the jaw relation, although that method can actually be presented as another modification of the Wits appraisal.

This new modification was represented by the line drawn perpendicular to the vertical dimension in profile radiographs taken in the natural position of the patient's head in the cephalostat – called the new reference extracranial line - true horizontal reference (HOR). The advantage of this extracranial line is that it is common for both dental bases. By obtaining this horizontal line, it was now possible to exclude the occlusal line and its defects from the analysis and obtain the so-called occlusal plane named - "Horizontal appraisal". This appraisal was used to analyze sagittal relationships in addition to the ANB angle.

In order to understand the relevance of this horizontal appraisal, a correlation was made with the ANB angle, performed for the entire sample and the horizontal appraisal showed a higher correlation coefficient than the conventional Wits appraisal. However, like the inadequacies of the abovementioned appraisals to analysis, this horizontal appraisal has its drawbacks. One of them is that the fixed vertical line necessary for the performance of the horizontal line (HOR) may vary during the recording, due to the position of the cephalometric film, weakened and unstable mechanical part of the cephalometer, etc. The dependence of the horizontal line (HOR) on obtaining a previously fixed vertical line during recording does not fully justify this appraisal as a substitute for the previous parameters, it also designates as an additional factor that can be taken into account in the analysis only. But, unlike other parameters for analysis, the author states that with this appraisal the time of analysis is extended, and that with this appraisal the number of possible mistakes is high, not only by the doctor who performs the analysis, but also by the radiologist who does the imaging. Although this appraisal correlates well with the ANB angle, due to the manner in which it is performed, many doctors consider it complicated, and it is therefore considered that this horizontal appraisal is not widely accepted. Although alternatives were sought to simplify it and minimize the possibility of human error, the same did not produce results for its wider use²³.

Conclusion

An increasingly dynamic and faster life leads doctors to strive for simplified and faster techniques of cephalometric analysis in everyday work. This is a big challenge in everyday life because the simple cephalometric technique does not always mean a reliable analysis technique. The desire to find a quick and accurate analysis was a leading factor in making all these studies, so that the best solution could be found. Knowing the key role of diagnosis in introducing good treatment and its outcome, the authors have conducted numerous studies. From the previously mentioned researches and analyses of the same, it can be seen that the analysis of the ANB angle is inevitable for the assessment of the sagittal relationship of the jaws. Although, the angle itself has many disadvantages such as dependence, and its variability on the age of the patient; the position of the nasion (N) point in both the antero-posterior and vertical directions; rotation of the SN plane; rotation of the maxilla or the mandible, or both jaws; change of SN-OP angle; as well as the degree of facial prognathism; it was not excluded from the daily analysis of the sagittal skeletal relations of the jaws. All this confirms that the ANB angle can be considered as a starting point and analysis point, which due to its shortcomings should be supplemented with the Wits appraisal. Although a correlation of these two parameters has been shown - the ANB angle and the Wits appraisal, we should take into account that in the same studies the analysis was performed on normodivergent patients, without vertical deviations in growth and development. This can confirm the justification for including the Wits appraisal as a supplementary analysis. The role and significance of the inclination of the occlusal plane is special, as well as its influence in the Wits appraisal. The dependence of this plane on dental parameters makes it quite unstable, but there is an optional solution for that, i.e., the inclusion of a modified Wits appraisal, especially in the group of patients with high FMA angle and increased lower anterior facial height. From all the above it can be seen that the sagittal relations are also influenced by the relations of the jaws in other planes. This should guide the therapist not to look at the analysis of these sagittal relationships in isolation, and therefore not to reduce it only to cephalometric sagittal analysis at the ANB angle, but after considering the other factors and analyses - the value of the FMA angle, the position of the occlusal plane, of the mandibular plane, the vertical growth of the face, etc., to include other parameters of the analysis of the sagittal relations - Wits appraisal or its modification, to obtain a complete comprehensive picture of the type and severity of the sagittal skeletal anomaly, thus enabling the establishment of a correct diagnosis, and planning an appropriate orthodontic therapy.

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