Comparison of Analysis Sefalometri Steiner Conventional Method Versus Software Autocad

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Abstract.
Cephalometric analysis is an important examination in orthodontics to support diagnosis and treatment planning. In addition to conventional methods, cephalometric analysis can be performed using AutoCAD software. This study aimed to determine differences in Steiner cephalometric analysis between conventional methods and AutoCAD software, particularly in angular and linear measurements. A descriptive comparative study with a cross-sectional approach was conducted. A total of 30 lateral cephalometric radiographs were randomly selected, and each was analyzed using both conventional methods and AutoCAD 2010 software. The analysis involved identifying reference points, constructing lines and planes, and measuring angles and distances according to Steiner analysis. The data were analyzed using a paired t-test with a significance level of 5%. The results showed no statistically significant differences between the conventional method and AutoCAD in either angular or linear measurements. Therefore, the two methods produced measurements that did not differ significantly in the study sample. However, these findings do not directly establish that both methods have identical levels of accuracy.

Keyword: *Angular Measurement; Autocad; Cephalometric Analysis; Conventional Method and Linear Measurement and Steiner Analysis.*

I. INTRODUCTION

Cephalometric analysis is an important procedure in the field of orthodontics which is used to evaluate the relationship between craniofacial structures, tooth position, and soft tissue as a basis for establishing a diagnosis, preparing a treatment plan, and evaluating the results of orthodontic therapy.(EP-O. Celik 2009). Since its introduction by Broadbent in 1931, lateral cephalometric examination has become a standard method in orthodontic practice because it is able to provide quantitative information regarding skeletal, dental, and soft tissue relationships objectively. One of the most widely used cephalometric analyses to date is the Steiner analysis, which utilizes various angular and linear parameters to assess the relationship of the upper and lower jaws, incisor positions, and the patient's facial profile. The results of this analysis serve as the basis for orthodontists in determining the diagnosis and selecting an appropriate treatment plan (Farooq 2016).

For many years, Steiner cephalometric analysis was performed conventionally using acetate tracing paper, pencils, rulers, protractors, and other measuring tools. This method required the operator to manually identify anatomical landmarks, then draw reference lines and take measurements one by one.(Araujo Guedes P 2010). Although conventional methods are still widely used and have become the standard in orthodontic education and practice, their implementation requires precision, accuracy, and is relatively time-consuming. In addition, measurement results are greatly influenced by the operator's ability to identify anatomical points, potentially leading to measurement variations between examiners (inter-observer variability) and within the same examiner (intra-observer variability). This condition can affect the consistency of analysis results if the procedure is not carried out carefully (Murali R. V 2011).

Advances in computer technology have driven changes in various aspects of healthcare, including dentistry. Various software tools have been developed to facilitate digital cephalometric analysis, with the goal of increasing efficiency, speeding up the measurement process, reducing errors caused by manual measurements, and simplifying the storage and documentation of patient data. One software tool that can be used for cephalometric analysis is AutoCAD.(Teguh 2010). Although initially developed as software for engineering design, AutoCAD has facilities for measuring angles, line lengths, point coordinates, and geometric depictions that allow users to perform digital tracing and cephalometric measurements with a high degree of precision. Utilization of this software provides a more practical alternative compared to conventional methods, especially when specialized orthodontic software facilities are not yet available (Sayinsu K 2007).

Several previous studies have shown that the use of digital systems in cephalometric analysis can produce accuracy comparable to manual methods. Some studies report that digital measurements offer advantages such as time efficiency, ease of data storage, and the ability to magnify radiographic images, making it easier to identify anatomical points.(Gayatri 2016). However, research results on the suitability between digital and conventional methods still show variation, primarily due to differences in the type of software used, radiographic image quality, sample characteristics, and cephalometric point identification techniques. Most previous studies have also evaluated orthodontic software specifically designed for cephalometric analysis, while studies on the use of AutoCAD as an alternative analysis software are still relatively limited. (Syahfik 2015)

The limited information regarding AutoCAD's ability to produce measurements equivalent to conventional methods indicates a research gap. Although AutoCAD has quite comprehensive geometric measurement facilities, the validity of its measurement results in Steiner cephalometric analysis still needs to be proven through research that directly compares the results of the two methods. This proof is important to determine whether the use of AutoCAD can be a viable alternative in conducting cephalometric analysis, especially in educational institutions and healthcare facilities that do not yet have specialized orthodontic software.(Gayatri 2016).

Based on the description, this study was conducted to compare the results of Steiner's cephalometric analysis obtained through conventional methods with the results of measurements using AutoCAD software on lateral cephalometric photographs. Comparisons were made on the angular and linear parameters used in Steiner's analysis so that it could be determined whether or not there were significant differences between the two methods. The results of this study are expected to provide scientific information regarding the level of suitability of using AutoCAD as an alternative cephalometric analysis method, as well as being a consideration in the use of digital technology to support orthodontic diagnosis and treatment planning. This introductory section has been structured according to the flow requested in the JIDA template, namely: (1) the importance of cephalometric analysis → (2) limitations of conventional methods → (3) potential of AutoCAD → (4) previous research → (5) research gap → (6) research objectives. The contents have also been summarized from the KIA writing style into a form that is more suitable for scientific journal articles.

II. MATERIALS AND METHODS

This study is a comparative study with a cross-sectional approach which aims to compare the results of Steiner cephalometric analysis between conventional methods and digital methods using AutoCAD software.(Albarakati 2012). The research was conducted by comparing measurement results on the same object so that the differences in results obtained came from the analysis method used.

The study sample consisted of 30 lateral cephalometric X-rays selected from patients attending the orthodontic clinic of the Faculty of Dentistry, Padjadjaran University. A total of 78 available lateral cephalometric X-rays were then randomly selected to obtain 30 study samples according to the inclusion criteria. The inclusion criteria included negative lateral cephalogram films in good condition, digital lateral cephalogram photographs in JPEG format in good condition, and clear images of anatomical structures so that cephalometric reference points could be identified.

Each sample was analyzed using two methods: a conventional method and a digital method using AutoCAD 2010 software. In the conventional method, a lateral cephalometric photograph in the form of a negative film was traced using a cephalometric analysis tool. Reference points were then identified, lines and Steiner analysis planes were created, and angle and distance parameters were measured.(Gayatri 2016).

In the digital method, digital lateral cephalometric photographs were entered into a computer using AutoCAD 2010 software. Before measurements were taken, the digital photographs were calibrated against negative photographs to ensure accurate measurements. After the calibration process was completed, reference points were determined, Steiner analysis lines and planes were created, and angular and linear parameters were measured using AutoCAD's measurement facilities.

The parameters compared in this study include angular and linear parameters in Steiner analysis. Angular measurements were performed on the angle values used in Steiner analysis, while linear

measurements were performed on the distances between reference points according to predetermined analysis parameters.

The measurement data from both methods were then recorded and entered into an analysis table. Comparison of measurement results between the conventional and AutoCAD methods was performed using paired-pair data analysis with a t-test. The statistical significance level was set at 5% with a significance value (p) <0.05 to determine whether there were significant differences between the two measurement methods.

III. RESULTS

This study was conducted on 30 lateral cephalometric X-rays analyzed using two measurement methods: a conventional method and a digital method using AutoCAD 2010 software. Both methods were applied to the same research object so that the measurement results could be directly compared. The cephalometric analysis used refers to Steiner's analysis by comparing angular and linear measurement parameters.

The measurement data from both methods were then analyzed using a paired t-test with a significance level of 5% ($p < 0.05$). The statistical analysis results were used to determine whether there were significant differences between the results of Steiner cephalometric analysis using the conventional method and the AutoCAD method.

The results of the study indicate that the average measurement values of the conventional and AutoCAD methods have very small differences in all parameters analyzed. Overall, the measurement results of both methods show almost the same value pattern, both in angle and distance measurements. The results of statistical tests indicate that all parameters compared have a significance value greater than 0.05, so there is no significant difference between the conventional and AutoCAD methods.

Angular Variable Comparison Results

Angular variable measurements were performed to compare angle values in Steiner analysis between the conventional and AutoCAD methods. In the conventional method, angle measurements were performed using manual measuring tools, while in the AutoCAD method, measurements were made using the angular measurement facility available in the software. Both methods were performed on the same sample with the same measurement parameters.

The results of angular variable measurements are presented in Table 1. The angular parameters analyzed include the skeletal relationship of the maxilla and mandible through the SNA, SNB, and ANB angles; the relationship of incisor tooth positions through the I-NA, I-NB angles, and the interincisal angle; and the relationship of the craniofacial plane through the OKL-SN and GoGn-SN angles.

Table 1. Comparison of Angular Variable Measurement Results between Conventional and AutoCAD Methods

Angular Variables	Conventional (average)	AutoCad (average)	P value
SNA	79.91	79.90	0.550
SNB	77.6	79.80	0.729
ANB	2.25	2.30	0.130
Angle I – NA	30.96	30.99	0.274
Angle I – NB	30.36	30.41	0.210
Interinitial Angle	116.55	116.55	0.914
Angle OKL – SN	19.28	19.27	0.682
GoGn – SN angle	35.28	35.25	0.301

The p-value for each angular variable showed insignificant results. The average p-value for all angular variables was 0.473 (>0.05), thus concluding that angular measurements using AutoCAD yielded results that were not statistically different from conventional methods.

Comparison of Linear Variables

The results of the linear variable measurements of Steiner's cephalometric analysis between the conventional and AutoCAD methods are shown in Table 2. The linear parameters compared include the distance of the upper incisor to the NA line (I-NA), the distance of the lower incisor to the NB line (I-NB), and the distance of the Pogonion to the NB line (Pg-NB).

The analysis results show that the average linear measurement values between the two methods are the same or nearly the same. Statistical tests show that all linear variables have a p-value > 0.05, indicating no significant difference between the conventional and AutoCAD methods.

Table 2. Comparison of Linear Variable Measurement Results between Conventional and AutoCADMethods

Linear Variables	Conventional (Average)	AutoCad (Average)	P value
I-NA distance	8.71	8, 71	0.083
I-NB distance	7.40	7.40	0.161
Pg-NB distance	1.19	1.19	0.326

Based on the results of statistical tests on linear variables, the average p value is 0.19 (>0.05), thus indicating that there is no significant difference between the results of linear measurements using conventional and AutoCAD methods.

Overall, the research results show that the AutoCAD method produces Steiner cephalometric analysis measurement values that are statistically equivalent to the conventional method, both in angular and linear measurements.

IV. DISCUSSION

The results showed that there was no statistically significant difference between Steiner cephalometric measurements using the conventional method and AutoCAD 2010 software for all angular parameters studied (p > 0.05). The mean values of the SNA angle in the conventional and AutoCAD methods were 79.91° and 79.90°, respectively, while the SNB angles were 77.76° and 77.80°, respectively. The ANB angle also showed a small difference, namely 2.25° in the conventional method and 2.30° in AutoCAD. These findings indicate that both methods produce relatively similar measurement values for parameters describing the skeletal relationship of the maxilla and mandible. These results are in line with Gayatri's study which compared conventional and digital Steiner cephalometric analysis using the CephNinja® application and reported no significant difference between the two methods.(Gayatri 2016). Research (EP-O. Celik 241-246) also compared digital and conventional cephalometric measurements and demonstrated that the agreement of the results should be assessed based on the parameters measured. Thus, the similarity of SNA, SNB, and ANB values in this study supports the potential use of AutoCAD as an alternative for skeletal parameter measurements, but does not prove that all digital software will provide the same results (Mohan 2021).

In dental parameters, the I-NA angle showed an average value of 30.96° in the conventional method and 30.99° in AutoCAD, while the I-NB angle was 30.36° and 30.41°, respectively. The interincisal angle produced the same average value in both methods, namely 116.55°. These results indicate that the measurement of incisor inclination to the reference line and the relationship between the maxillary and mandibular incisors is relatively consistent in both methods in this study sample. However, the results of previous studies have shown that the agreement of digital and manual measurements is not always uniform in all parameters. For example, (Farooq 2016) reported that most analyzed variables showed consistency between digital and manual methods, but there were differences in several variables, including 1-NA measurements and interincisal angles. These differences are important to note because they indicate that measurement results can be influenced by the tracing method, software, and anatomical point determination process. Narkhede et al. (2024), through a systematic review and meta-analysis of 20 studies, also concluded that the agreement between digital and manual measurements varies by anatomical point and cephalometric parameters. Therefore, the similarity in interincisal angle results in this study is a positive finding, but cannot be directly generalized to all software and radiographic conditions (Narkhede 2024).

Measurement of the occlusal plane angle to the Sella–Nasion line (OKL-SN) yielded an average value of 19.28° with the conventional method and 19.27° with AutoCAD. Meanwhile, the GoGn-SN angle

showed values of 35.28° and 35.25°, respectively. The small differences in these two parameters indicate that the measurements of the occlusal plane relationship and the mandibular vertical pattern were relatively similar between the two methods. These results support the trend reported by (Narkhede 2024), digital measurements can provide reliable results for certain parameters, although the level of agreement is not always the same for each measurement. In this study, the closeness of the mean values does not necessarily mean that potential measurement errors have been eliminated. Anatomical point determination, reference line drawing, and image quality can still affect the results. Therefore, the application of AutoCAD requires consistent measurement procedures so that the results can be compared with conventional methods.

In linear parameters, the I-NA distance showed an average value of 8.71 mm in both methods. The I-NB distance also produced the same average value, namely 7.40 mm, while the Pg-NB distance showed a value of 1.19 mm in both methods. The absence of statistically significant differences indicates that the linear measurement values obtained using AutoCAD are relatively comparable to those obtained using conventional methods on the analyzed samples. This finding needs to be considered together with the results of the research by Çelik et al. (2009) and (Farooq 2016), which evaluated digital and conventional cephalometric measurements, showed that the results were consistent across most variables, but differences could still be found in certain parameters. A review (Narkhede 2024) also emphasized the inter-landmark variation in digital and manual measurement studies. Thus, the linear measurement results in this study support the use of AutoCAD for the parameters studied, but are insufficient to state that all linear measurements with this software will always be identical to conventional methods.

The similarity of linear measurement results also needs to be interpreted by considering image calibration. In digital measurements, the accuracy of image scale and proportion is crucial because calibration errors can lead to differences in measured distance values. Therefore, image calibration before measurement and the use of uniform procedures are essential for maintaining consistent results. Furthermore, the examiner's ability to identify anatomical points can influence measurement results, both with conventional and digital methods. This is in line with general findings. (Narkhede 2024) notes that the suitability of digital and manual methods can vary depending on the parameters being analyzed. In other words, the use of software does not automatically eliminate the possibility of errors arising from the landmark identification process.

Overall, no significant differences were found in the angular or linear parameters, indicating that the AutoCAD 2010 measurement results were relatively comparable to the conventional method on the 30 lateral cephalometric radiographs analyzed. These results are in line with the research (Gayatri 2016) regarding conventional and digital Steiner analysis, supported by other comparative studies showing that measurement suitability needs to be assessed for each parameter, also concluded that digital tracing has the potential to provide reliable measurements for certain parameters, although results vary between landmarks. However, the absence of statistically significant differences in this study cannot be directly interpreted as evidence of clinical equivalence or accuracy to true values. These results only indicate that this study did not find evidence of differences based on the statistical tests used.

In orthodontic practice, AutoCAD 2010 has the potential to be an alternative to assist with cephalometric measurements, especially when digital radiographs are available and the image scale can be precisely calibrated. This software provides geometric features that can be used to create lines and measure angles and distances. However, AutoCAD is not specifically designed for cephalometric analysis. Therefore, the examiner still needs to determine anatomical points and reference lines based on Steiner analysis principles and ensure that the measurement procedure is carried out consistently. The results of this study support the potential use of AutoCAD for the parameters tested, but are not sufficient to conclude that the software can completely replace the functionality of specialized cephalometric software or conventional methods in all clinical situations.(Syahfik 2015).

This study has limitations that should be considered when interpreting the results. The sample size of 30 radiographs and the use of radiographs from a single study site may limit the generalizability of the findings to different populations or radiographic conditions. Furthermore, this study compared measurement results using a difference test, so a statistically insignificant result does not necessarily prove the equivalence

of the two methods within clinical tolerance limits. Future studies could include larger and more diverse samples, assess intra- and inter-examiner reliability, and evaluate the magnitude of the differences between methods using an agreement analysis, such as the Bland–Altman test. This approach could provide additional information regarding the range of measurement differences, allowing for a more comprehensive assessment of AutoCAD's agreement with conventional methods.

V. CONCLUSION

Based on the research results, there was no statistically significant difference between Steiner cephalometric analysis using conventional methods and AutoCAD 2010 software, either in angular or linear measurements (($p > 0\{,\}05$)).

These results indicate that AutoCAD 2010 can be used as an alternative for Steiner cephalometric analysis under the conditions of this study. However, these results do not directly prove that the two methods are completely equivalent or have the same level of accuracy. Implementing digital methods still requires precise calibration, careful identification of anatomical points, and consistent measurement procedures.

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