COMPARISON OF THE ACCURACY OF MANUAL CEPHALOMETRY RADIOGRAPHIC MEASUREMENTS AND WEB-BASED DIGITAL SOFTWARE

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ABSTRACT
Background: *Determining anatomical landmarks - in the cranium, maxilla and mandible - as well as measuring skeletal and dental angles on cephalometric radiographs are supporting examinations that determine important diagnoses in orthodontic treatment. Traditionally, cephalometric analysis has been performed by tracing radiographic landmarks on acetate overlays and measuring linear and angular variables using protractor. However, despite its widespread use in orthodontics, the technique is time consuming and has several drawbacks, including a high risk of error in tracing, landmark identification, and measurement.* ***Objective****: to evaluate the difference of cephalometric measurements using manual and digital technique.* ***Method****: pre-treatment cephalometric digital radiographs of 40 patients were traced manually and digitally using WebCeph Ver. 1.0.0 computer software program by the same investigator. A total of 8 anatomical landmarks were located and five angular measurements based on Steiner Analysis were measured. Independent t-tests and Mann-Whitney tests were used to compare the difference of manual and digital measurements.* ***Result****: the p-values for SNA, SNB, ANB, I-NA, I-NB were greater than 0.05 (p>0.05).* ***Conclusion****: There were no significant difference between manual and digital tracing cephalometric technique using WebCeph for SNA, SNB, ANB, I-NA and I-NB*

Keywords: *Cephalometric measurement, Digital cephalometric analysis, Steiner Analysis, Tracing cephalometry, WebCeph*
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INTRODUCTION

Cephalometric radiography is an important supporting examination in determining skeletal and dental diagnoses, as well as in evaluating before and after orthodontic treatment. Determining the identification of landmarks and measuring dentoskeletal angles on acetate paper is a manual method which been known to have weaknesses in several ways, namely time consuming, errors in identifying anatomical landmarks, errors in interpretation, errors in diagnosis can lead to errors in determining the type and plan of orthodontic treatment.[1-6] Digital cephalometric radiography can be an alternative in identifying anatomical landmarks, determining skeletal and dental and soft tissue diagnoses, so that it can help in determining the type and treatment plan in the field of orthodontics quickly and accurately.[7] However, digital measurements are also not free from shortcomings, namely if the cephalometric photo is distorted or determines the wrong point, errors will occur in interpreting the diagnosis of an orthodontic case.[8] For this reason, it is necessary to compare the measurement results of the two cephalometric radiography analysis techniques in determining the identification of anatomical landmarks and the accuracy of measuring dentoskeletal angles because the results of these measurements are very important in the orthodontic diagnosis process and influence the orthodontic treatment plan.

MATERIALS AND METHODS

This research has received a recommendation for ethical approval from Indonesian Muslim University

number: 634/A.1/KEP-UMI/I/2024. This type of research is descriptive analytic with a cross sectional approach. This research was conducted at Kimia Farma Cendrawasih Dental Clinic, Makassar. The population of this study was the cephalogram of patients before undergoing orthodontic treatment at Kimia Farma Cendrawasih Dental Clinic, Makassar. The sample size was determined using the Slovin formula with an error rate of 5% so that the sample size in this study was 39.7 and rounded to 40.

RESULTS

Table 1. SNA Descriptive Analysis

Group SNA	Mean	Std. Deviation
manual	81.225	4.505
digital	82.758	3.506

The SNA angle based on Steiner analysis describes the position of the maxilla relative to the base of the cranium. Manual measurement results show an average SNA angle value of 81,225 with a standard deviation of 4,505 and digital measurement results show an average SNA angle value of 82,758 with a standard deviation of 3,506, resulting in a difference in angle measurements of 1,533.

Table 2. SNB Descriptive Analysis

Group SNB	Mean	Std. Deviation
manual	79.088	4.890
digital	79.735	3.859

The SNB angle based on Steiner analysis describes the position of the mandible relative to the base of the cranium. The results of manual measurements show an average value of the SNB angle of 79,088 with a standard deviation of 4,890, apart from that the measurement results digitally shows the average value of the SNB angle of 79.735 with a standard deviation of 3.859 and a difference in angle measurements of 0.647.

Table 3. ANB Descriptive Analysis

Group ANB	Nean	Std. Deviation
Manual	2.163	3.407
Digital	3.050	3.263

The ANB angle based on Steiner analysis describes the position of the maxilla and mandible relative to the base of the skull. Manual measurement results show an average ANB angle value of 2,163 with a standard deviation of 3,407, while digital measurement results show an average ANB angle value of 3,050 with a standard deviation of 3,263 and a difference in angle measurements of 0.887.

Table 4. Descriptive Analysis I-NA

Group I-NA	Mean	Std. Deviation
Manual	29.463	9.103
Digital	28.673	9.419

The I-NA angle in Steiner analysis describes the position of the maxillary incisors relative to points N and A. The results of manual measurements show an average value of the I-NA angle of 29.463 with a standard deviation of 9.103, while the results of digital measurements show an average value of the angle I-NA is 39.419 with a standard deviation of 9.41 and there is a difference in angle measurements of 0.790.

Table 5. Descriptive Analysis I-NB

Group I-NB	Mean	Std. Deviation
Manual	30.388	7.251
Digital	30.234	9.573

The I-NB angle in the Steiner analysis describes the position of the maxillary incisors relative to points N and B. The results of manual measurements show an average value of the I-NB angle of 30,388 with a standard deviation of 7,251, while the results of digital measurements show an average value of the angle I-NB is 30.234 with a standard deviation of 9.573 and there is a difference in angle measurements of 0.154.

Table 6. Data Normality Test

Angle	Group	Kolmogorov-Smirnov[a]		
		Statistic	df	p-value
SNA	manual	0.099	40	0.200[*]
	digital	0.093	40	0.200[*]
SNB	manual	0.132	40	0.079
	digital	0.131	40	0.082
ANB	manual	0.138	40	0.054
	digital	0.166	40	0.007
I-NA	manual	0.105	40	0.200[*]
	digital	0.127	40	0.102
I-NB	manual	0.129	40	0.092
	digital	0.134	40	0.068

Based on table 6, the results of the normality test show that in the SNA group, the manual measurement obtained a p-value of 0.200 and a digital p-value of 0.200, which is greater than 0.05 (p-value > 0.05), this shows that the angle value in the SNA group is normally distributed. The comparison test was carried out using the independent t-test.

The results of the normality test show that in the SNB group, the manual measurement obtained a p-value of 0.079 and digital p-value of 0.082, which is greater than 0.05 (p-value > 0.05), this shows that the angle values in the SNB group are normally distributed so the comparison test was carried out using independent t-test.

The results of the normality test showed that in the ANB group, manual measurements obtained a p-value of 0.054 which was greater than 0.05 (p-value > 0.05), this shows that the angle values in the ANB group were normally distributed. The p-value result for digital measurements was 0.007 which was greater than 0.05 (p-value > 0.05), this shows that the angle values in the ANB group were not normally distributed so the comparison test was carried out using the Mann-Whitney test.

The results of the normality test show that in the I-NA group, the manual measurement obtained a p-value of 0.200 and digital p-value of 0.102, which is greater than 0.05 (p-value > 0.05), this shows that the angle value in the I-NA group is normally distributed and The comparison test was carried out using the independent t-test. The results of the normality test show that in the I-NB group, manual measurements obtained a p-value of 0.092 and digital p-value of 0.068, which is greater than 0.05 (p-value > 0.05), this shows that the angle values in the I-NB group are normally distributed so that The comparison test was carried out using the independent t-test.

Table (7) Comparison Test

Angle	Measurement technique	N	Mean	Std. Deviation	p-value
SNA	manual	40	81.225	4.505	0.093 a
	digital	40	82.758	3.506	
SNB	manual	40	79.088	4.890	0.513 a
	digital	40	79.735	3.859	
ANB	manual	40	2.163	3.407	0.083 b
	digital	40	3.050	3.263	
I-NA	manual	40	29.463	9.103	0.704 a
	digital	40	28.673	9.419	
I-NB	manual	40	30.388	7.251	0.936 a
	digital	40	30.234	9.573	

a: Independent T test, b: Mann-Whitney test

Based on table 7, when measuring SNA angles using manual and digital techniques, there is a difference in measurements of 1.533 and the results of the comparison test show a p-value of 0.093 which is greater than 0.05 (p-value > 0.05), this shows that there is no significant difference in the results. SNA angle measurements between manual and digital techniques.

In measuring the SNB angle using manual and digital techniques, there was a measurement difference of 0.647 and the results of the comparison test showed a p-value of 0.513 which was greater than 0.05 (p-value > 0.05), this shows that there was no significant difference in the results of measuring the SNB angle between manual and digital techniques.

The results of manual and digital ANB angle measurements show a difference in value of 0.887. The results of the comparison test show a p-value of 0.083 which is greater than 0.05 (p-value > 0.05), this shows that there is no significant difference in the ANB angle measurement results between manual and digital techniques.

The results of measuring the angle of the maxillary incisors to points N and A (I-NA) manually and digitally show a difference in value of 0.790. The results of the comparison test show a p-value of 0.704 which is greater than 0.05 (p-value > 0.05), this shows that there is no significant difference in the I-NA angle measurement results between manual and digital techniques.

The results of manual and digital I-NB angle measurements show a difference in value of 0.154. The results of the comparison test show a p-value of 0.936 which is greater than 0.05 (p-value > 0.05), this shows that there is no significant difference in the results of I-NB angle measurements between manual and digital.

DISCUSSION

Cephalometric radiography is an important tool for determining growth and development patterns of the facial skeleton, diagnosis and treatment planning, as well as evaluation before and after orthodontic treatment.[9] This study aims to determine the comparison of the accuracy of cephalometric radiography measurements between manual (conventional) techniques and web-based digital software in this study using WebCeph Ver 1.0.0. Alqahtani[9] in his study, noted that cloud-based cephalometric analysis is a practical method because it is fast, easy to store documents, does not require installation, and is easily accessible on all website platforms. This study used 40 samples of lateral cephalometric radiographs and digital files before orthodontic treatment. Digital files obtained directly from the clinical laboratory were chosen to avoid distortion of lateral cephalometric photographs because this could affect the measurement results.

Traditionally, cephalometric analysis has been performed by tracing radiographic markers on acetate paper and measuring linear and angular variables using a protractor. Even though this technique is widely used in the field of orthodontics, it takes a long time and has several disadvantages, including the high risk of errors in tracing, errors in identifying landmarks, which in turn causes incorrect angle measurements.[7,9]

Reproducibility of measurements by the operator is also an important factor in determining measurement accuracy. Recently, technological advances have made it possible to trace cephalograms using a computer. The use of computers is not only expected to reduce the incidence of individual errors but also to provide standardized, rapid, and accurate evaluations with high reproducibility rates.[7,10,11]

The results of measuring the SNA, SNB, ANB, I-NA and I-NB angles in this study showed that there were no significant differences between manual techniques and digital cephalometric tracing. This is in accordance with other research using the 3-dimensional program Dolphin version 11.0 using artificial intelligence V8 software, revealing that the average angle values of SNA, SNB, ANB, SN-MP, U1-SN, L1-NB, SNPg, ANPg, SN/ ANS-PNS, SN/GoGn, U1/ANS-PNS, L1-APg, U1-NA, and L1-GoGn were not significantly different compared to

the manual technique.[12] The results of other studies show that digital cephalometric analysis using non-automatic techniques shows that there are no significant differences in results, although there are differences in several parameters. To minimize the margin of error in artificial intelligence-based automated cephalometric software, manual intervention from the observer is still required.[13] Similar conclusions from research results using automated and semi-automated WebCeph reveal that this software is poor at identifying landmarks or poor soft tissue tracking and measurement inconsistencies. The use of cephalometric analysis using WebCeph must be used very carefully and requires manual intervention from the observer. 14 Even though artificial intelligence is used, manual adjustments to landmark positions sometimes still have to be done to get accurate results in lateral cephalometric analysis.[14,15] The limitation of this research is that it only describes the SNA, SNB, ANB, I-NA and I-NB angles, so further research needs to be done regarding other landmark cephalometric indicators, both angular and linear. This research also only uses one type of cephalometric analysis software so it needs to be compared with other cephalometric analysis software. There was no significant difference between manual techniques and digital cephalometric tracing using WebCeph Ver 1.0.0 at the SNA, SNB, ANB, I-NA and I-NB angles.

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