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Research Article

Comparison of Cephalometric Measurements Between Hand Tracing and Digital Tracing Based on Android OneCeph

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Abstract

Lateral cephalometric radiographic examination is one of the supporting examinations in orthodontic treatment. Cephalometric measurements can be performed using hand tracing (manual) and digital methods. The digital method is widely preferred today due to its faster measurement, easy and safe storage, and can be sent anywhere easily. One of the applications that can be utilized for digital analysis is OneCeph. This application's accuracy for cephalometric analysis, therefore, needs to be evaluated. This study aims to determine the differences in cephalometric measurements using the Ricketts method between hand tracing and digital tracing based on the OneCeph Android application. This analytic observational study utilized a cross-sectional design conducted at the Dental Hospital of UMY. The samples were 30 lateral cephalometric radiographs of good quality and had film negatives and digital files. The Ricketts method analysis was carried out manually and digitally utilizing the OneCeph application. The Shapiro Wilk test results showed that the data were normally distributed for all components except for the convexity of point A, lower incisor to A Pog line, and e-line. Comparative test results with independent sample t-test and Mann-Whitney test demonstrated no significant difference in all components ($p>0.05$), except for the variable lower incisor to A Pog line ($p<0.05$). The multivariate analysis results also showed $p>0.05$, demonstrating no significant difference for all components ($p>0.05$). The OneCeph application is no different from the gold standard (hand tracing/manual method) that has been used so far, so it can be an alternative for cephalometric tracing.

Keywords: orthodontics; cephalometry; hand tracing; digital tracing; OneCeph

INTRODUCTION

Orthodontics is a treatment in the field of dentistry to treat craniofacial, dentofacial growth, dental occlusion relationships, and facial esthetics.[1] Based on the Riset Kesehatan Dasar (Riskesdas) report in 2013, there were 14 provinces in Indonesia experiencing dental and oral problems at 25.9%. The prevalence of malocclusion in Indonesia is still very high, around 80% of the population.[2] Wustha and Irvan (2019), according to the results of their research, stated that the prevalence of malocclusion in children aged 9-11 years at SD IT Insan Utama Yogyakarta was 57.3% for class I Angel malocclusion; 41.6% Angel class II malocclusion and 3.3% Angel class III malocclusion. The prevalence of malocclusion in boys is 61.7%, while in girls is 38.3%.[3]

Orthodontic treatment requires supporting examinations in the form of radiography as a diagnostic tool. One way to obtain radiographic images that function to make treatment plans and check the progress of patients undergoing orthodontic treatment is cephalometric radiography.[4] In general, two cephalograms are known, namely the lateral cephalogram and the frontal/postero-anterior cephalogram. A

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lateral cephalogram was with a two-dimensional (2D) view of the anteroposterior position of the teeth, the inclination of the incisors, the position and size of the bony structures supporting the teeth, and the skull base, while the frontal/posteroanterior cephalogram as an adjunct is needed to identify better which hard tissue structures are involved in asymmetry.[5]

Cephalometric studies of quantitative measurements is used to obtain information about craniofacial patterns. The benefits of cephalometry are that it can be a diagnostic tool and an evaluation tool in the fields of pedodontics, prosthodontics, orthodontists, oral surgeons, and general dentists.[6] Cephalometric measurements are very helpful for orthodontists in the case of diagnosis, treatment planning, treatment, and identifying changes after orthodontic treatment.[7] Shulchan et al., according to their research about changes in facial profile after fixed orthodontic treatment using lateral cephalometric analysis, revealed there were changes in the occlusal plane angle before and after treatment of 2°– 5° and changes in facial height index before and after treatment of 0.018 – 0.084 mm in orthodontic treatment of class II division 1 malocclusion using the Begg technique.[8]

Cephalometric measurements can be carried out in two versions, i.e., the hand tracing or manual method and the digital method. This manual method is extensively utilized in cephalometric measurements but is quite time-consuming and has several drawbacks, such as the risk of errors in tracking, measuring, and identifying landmarks. Meanwhile, digital cephalometric measurements are widely preferred nowadays as they have several advantages over those of using the hand tracing method, including faster measurements, easier treatment plans to determine, easy and safe image storage, and can be sent anywhere easily.[9] Several studies have been conducted to compare these two methods. Research conducted by Sayar & Kilinc (2017) revealed a significant difference between cephalometric tracing using the manual method and using the CephNinja application. Cephalometric tracing is faster with the CephNinja application method compared to the manual method.[10]

Furthermore, several analytical methods employed to perform cephalometric measurements encompassed the Down, Wendel Wylie, Steiner, Ricketts, Tweed, and Holdaway methods.[11] Of the various cephalometric measurement methods, the researchers selected the Ricketts method since it is simple and easy to apply.[12] Ricketts analysis is one of the cephalometric analysis methods, was created by Robert Ricketts, who is an expert on craniofacial anatomy, physiology, and facial development in humans.[13] The Ricketts method generally uses a number of parameters such as facial axis, facial depth angle, mandible, convexity of point A, lower incisor angle to A-Pog, upper molar to PtV, lower incisor distance to A-Pog, and lower lip to the aesthetic line.[14] The hallmark of the Ricketts method is the aesthetic line created by a line drawn from the pogonion (Pog) to the tip of the nose (Pr). Ricketts also devised a method of facial convexity and height from within the facial skeleton.[15]

Moreover, several smartphone-based applications for measuring cephalometrics include OneCeph, CephNinja, EasyCeph, and OrthoCeph. In this case, the OneCeph utilized in this study was an Android-based application with programs for analyzing cephalometrics, such as Down, Steiner, Ricketts, Tweed, Holdaway, Jabarak, McNamara, Schwarz, Yen angle, Beta angle, and Wits Appraisal. OneCeph is also one easy-to-use mobile software since it is operated on mobile phones, especially Android, so it is easy to carry, lightweight, practical to operate anywhere, and measurements can be done automatically. However, this application's accuracy for cephalometric analysis needs to be evaluated.

MATERIALS AND METHODS

This analytic observational study employed a cross-sectional design and was conducted at the Dental Hospital, Universitas Muhammadiyah Yogyakarta (UMY). The samples used in this study were 30 lateral cephalometric radiographs of patients from the Dental Hospital of UMY and lateral cephalometric radiographs of patients from private orthodontic practice, with good quality, negative films, and digital files. The sampling technique utilized was purposive sampling.

Thirty lateral cephalometric radiographic films were analyzed using the Ricketts method with manual cephalometric analysis techniques and then digital techniques utilizing the OneCeph Android-based application (Figure 1). Manual cephalometric tracing was carried out using a cephalogram printed on film paper. Furthermore, by using acetate paper on top, tracing was carried out using a 4H pencil with the help of an illuminator for lighting. OneCeph is a free Medical app developed by NXS, Kamineni Institute of Dental Sciences, Narketpalley, Nalgonda(dt) Telangana, India. The latest version of OneCeph is beta 12, which was released on 2019-10-20 (updated on 2020-09-20).

This study utilized 11 components in the Ricketts method: Facial axis angle, Mandibular plane angle, Facial taper, Lower facial height angle, Mandibular arc angle, Convexity of point A, Lower incisor to A-Pog line, Lower incisor inclination, Upper molar to PTV, Interincisal angle (IIA), Lower lip, and E-line (Figure 2).

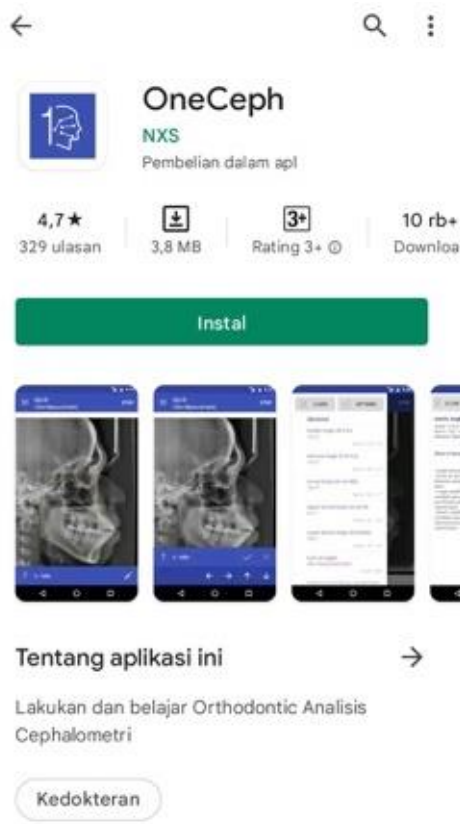

Figure 1. OneCeph application

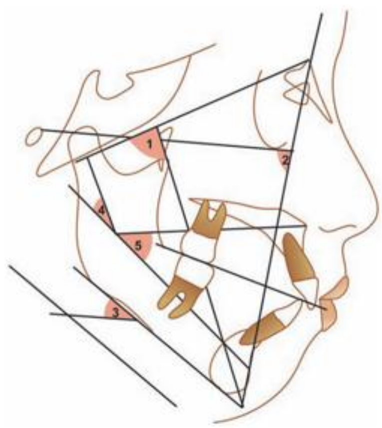

Figure 2. Ricketts analysis. (1) Facial axis, (2) Facial depth, (3) Mandibular plane angle, (4) Lower facial height, and (5) Mandibular arc (Premkumar, 2015)

The research data were analyzed using SPSS, including the Shapiro-Wilk normality test, independent sample t-test/Mann-Whitney Test, and multivariate analysis.

RESULT

The results of the two analyses are presented in Table 1.

Table 1. Research Results of Variable Group

Variable	Group	N	Mean (°)
Facial Axis Angle	Manual	30	84.867
	Digital	30	85.037
Mandibular Plane Angle	Manual	30	27.967
	Digital	30	27.623
Facial Taper	Manual	30	66.967
	Digital	30	66.910
Lower Facial Height Angle	Manual	30	41.667
	Digital	30	41.107
Mandibular Arc Angle	Manual	30	27.900
	Digital	30	28.117
Convexity of Point A	Manual	30	3.433
	Digital	30	3.127
Lower Incisor to A Pog Line	Manual	30	3.507
	Digital	30	2.430
Lower Incisor Inclination	Manual	30	25.567
	Digital	30	25.393
Upper Molar to Ptv	Manual	30	15.233
	Digital	30	15.070
Interincisal Angle	Manual	30	125.400
	Digital	30	124.970
Lower Lip and E-Line	Manual	30	1.833
	Digital	30	1.620

The analysis results were tested for normality using Shapiro-Wilk. The normality test results are shown in Table 2.

Table 2. Normality Test Results of Variable Group in Description Comparison Test

Variable	Group	N	P-Value	Comparison Test
Facial Axis Angle	Manual	30	0.960*	Independent test
	Digital	30	0.666*	
Mandibular Plane Angle	Manual	30	0.827*	Independent test
	Digital	30	0.879*	
Facial Taper	Manual	30	0.805*	Independent test
	Digital	30	0.549*	
Lower Facial Height Angle	Manual	30	0.763*	Independent test
	Digital	30	0.996*	
Mandibular Arc Angle	Manual	30	0.102*	Independent test
	Digital	30	0.120*	
Convexity of Point A	Manual	30	0.000	Mann Whitney
	Digital	30	0.161*	
Lower Incisor to A Pog Line	Manual	30	0.022	Mann Whitney
	Digital	30	0.024	
Lower Incisor Inclination	Manual	30	0.337*	Independent test
	Digital	30	0.206*	
Upper Molar to Ptv	Manual	30	0.757*	Independent test
	Digital	30	0.681*	
Interincisal Angle	Manual	30	0.265*	Independent test
	Digital	30	0.231*	
Lower Lip and E-Line	Manual	30	0.003	Mann Whitney
	Digital	30	0.000	

Based on Table 2, the normality test results from cephalometric measurements of facial axis angle, mandibular plane angle, facial taper, lower incisal height angle, mandibular arc angle, lower incisor inclination, upper molar to PTV, and interincisal angle in manual cephalometric analysis and digital cephalometric analysis using OneCeph obtained a significance value of p>0.05 (marks with*). It indicated that the data were normally distributed. Meanwhile, in the convexity of point A, lower incisor to A Pog line, and e-line measurements in manual cephalometric analysis and digital cephalometric analysis using OneCeph, a significance value of p<0.05 was obtained, indicating that the data were not normally distributed. Therefore, the eight variables with normally distributed data were analyzed using the independent sample t-test to identify the differences in the manual and digital cephalometric analysis measurement results utilizing Oneceph. Meanwhile, the convexity of point a, lower incisor to a Pog line, and e-line were analyzed using the Mann-Whitney Test. The comparative test results are shown in Table 3.

Table 3. Comparison of Test Results of Variable Group

Variable	Group	N	T-value	P-value
Facial Axis Angle	Manual	30	-0.152	0.880*
	Digital	30		
Mandibular Plane Angle	Manual	30	0.244	0.808*
	Digital	30		
Facial Taper	Manual	30	0.054	0.957*
	Digital	30		
Lower Facial Height Angle	Manua	30	0.503	0.617*
	Digital	30		
Mandibular Arc Angle	Manual	30	-0.146	0.884*
	Digital	30		
Convexity of Point A	Manual	30	399.50	0.454*
	Digital	30		
Lower Incisor to A Pog Line	Manual	30	313.00	0.042*
	Digital	30		
Lower Incisor Inclination	Manual	30	0.103	0.919*
	Digital	30		
Upper Molar to Ptv	Manual	30	0.138	0.891*
	Digital	30		
Interincisal Angle	Manual	30	0.127	0.899*
	Digital	30		
Lower Lip and E-Line	Manual	30	443.500	0.923*
	Digital	30		

Based on Table 3, all components of the cephalometric measurement demonstrated a value of p>0.05 (marks with*). These results suggest that no significant difference existed between the manual cephalometric and the digital cephalometric analysis groups using OneCeph in all components. Furthermore, to compare the overall cephalometric analysis, data were tested using multivariate analysis. The multivariate analysis results are shown in Table 4.

Table 4. Multivariate Test Results of Statistic test

Statistic test	Statistic	P-Value
Pillai's Trace	0.097	0.913
Wilks' Lambda	0.903	0.913
Hotelling's Trace	0.108	0.913
Roy's Largest Root	0.108	0.913

Based on Table 4, the multivariate test results revealed a p-value of 0.913, i.e., p>0.05. It indicated that the measurements taken as a whole in the two tracing groups did not show a significant difference.

DISCUSSION

This study utilized 30 lateral cephalogram samples that had negative films and digital files, similar to previous research, which also used 30 samples to compare manual and digital cephalometric analysis.[16] Based on Table 2, the independent sample t-test results uncovered no significant difference between manual cephalometric measurements and digital cephalometric analysis utilizing OneCeph for facial axis angle, mandibular plane angle, facial taper, lower facial height angle, mandibular arc angle, lower incisor inclination, upper molar to PTV, and interincisal angle, indicated by a p-value of >0.05. It aligns with a previous study that compared cephalometric measurements using digital and manual analysis.[17] The study results demonstrated no significant difference between the two analyses. The research also explained the advantage of OneCeph, i.e., having the same accuracy level as manual analysis. It is one of the reasons for the absence of a significant difference between digital and manual cephalometric measurements.

Moreover, the Mann-Whitney Test results demonstrated no significant difference between manual cephalometric analysis and digital cephalometric analysis using OneCeph, showing p>0.05, except for the lower incisor to a Pog line. At the lower incisor to the A Pog line, p<0.05 indicated a significant difference between the two analyses. In this case, the lower incisor to a Pog line was formed by the incisal point on the mandibular incisor to the line connecting point A to the pogonion point. In a previous study, identifying landmarks from lower incisors had a statistically significant difference as the zoom-in function of OneCeph was very sensitive when identifying landmarks from mandibular incisors.[18] According to prior research, identification of point A is also often in error since point A is adjacent to the soft tissue near the anterior nasal spine, which casts a shadow on X-rays, making identification in the OneCeph application more difficult.[11] These two factors could cause a significant difference in the variable lower incisor to a Pog line.

Based on Table 4, the four multivariate analysis methods, namely Pillai's Trace, Wilk's Lambda, Hotelling's Trace, and Roy's Largest Root, show p> 0.05. It denotes that the overall cephalometric variables in the manual and digital cephalometric analyses using OneCeph did not significantly differ. This study's results align with research by Faliya et al. (2021), revealing no significant difference between manual cephalometric analysis and digital cephalometric analysis using OneCeph on 40 radiographs using Tweed analysis.[17] Thus, it was concluded that OneCeph is relatively accurate compared to manual cephalometric analysis.

Furthermore, it is also consistent with previous research demonstrating no significant difference between manual cephalometric analysis and digital cephalometric analysis using OneCeph. Their research compared the duration of manual and digital cephalometric measurements using the OneCeph application.[10] Analysis was performed on 35 cephalometric radiographs measuring eight skeletal, five dental, and three soft tissue measurements. Likewise, it also corroborates with other studies, which explained no significant difference since all parameters had a p-value>0.05, both digital cephalometric measurements carried out using the OneCeph application and manual cephalometric measurements. The study also compared the reliability and accuracy of digital cephalometric measurements performed utilizing the OneCeph application with manual cephalometric measurements using 20 pre-treatment lateral cephalometric radiographs of subjects. They came to a postgraduate orthodontic clinic for orthodontic treatment for more than one month. Cephalometric measurements were performed using the OneCeph application to evaluate the nine parameters of Steiner's cephalometric analysis.[19]

Manual cephalometric analysis was carried out by manual measurement using a caliper and protractor. This analysis was one of the shortcomings since the operator had limitations in making measurements and was less accurate than digital cephalometric analysis. On the other hand, in digital cephalometric analysis, OneCeph was utilized. It is mobile software that is easy to use, fast, saves time, and has other advantages. They included free of charge in conducting cephalometric analysis, carrying out unlimited measurements, and even performing cephalometric analysis on a smartphone without an internet connection. Thus, it can be utilized in conducting studies in rural centers with less internet access. Meanwhile, the weakness of OneCeph is that this application's availability is only found on Android-based smartphones, and the measurement uses a semi-automatic method.[20]

Furthermore, manual tracing and OneCeph have similarities in the anatomical landmark points determined by the operator manually, while the measurement of angles and distances is done automatically in OneCeph with a faster time than manual tracing. It makes this application semi-automatic, so there is no significant difference between manual tracing and digital tracing utilizing OneCeph. Hence, the OneCeph application can make it easier for operators to obtain results from measurements and reduce measurement error rates.

CONCLUSION

Based on the research results, it can be concluded that there was no significant difference between manual cephalometric analysis and digital cephalometric analysis based on Android OneCeph. Thus, it can be an alternative to cephalometric tracing.

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