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Research Report

A comparison between orthodontic model analysis using conventional methods and iModelAnalysis

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ABSTRACT

Background: *Model analysis constitutes an essential aspect of orthodontic diagnostic practice. Pavan has developed an application to simplify the mathematical calculations employed in orthodontic model analysis.* ***Purpose:*** *This study was conducted to obtain the differences in results and time periods of model analysis using conventional means and iModelAnalysis.* ***Methods:*** *The research represented a comparative analytic study. The populations comprised dental casts dating from 2014 in the Orthodontics Laboratory of Padjadjaran University. The samples comprised 31 dental casts which were subjected to a total sampling method consisting of two treatments; a conventional method calculation and one using iModelAnalysis. A normality test was conducted and processed using a paired t-test with α=0.05.* ***Results:*** *The means of arch length discrepancies were 1.64±2.63 mm and 1.37±3.07 mm for the conventional methods and 1.65±2.43mm and 1.42±3.04mm for iModelAnalysis. The results of a Bolton analysis for conventional methods were 78.05±2.69% and 91.93±1.29%, while those for iModelAnalysis were 77.91±2.70% and 91.96±2.13%. A Howes analysis of conventional methods produced a result of 45.56±2.83%, while for an iModelAnalysis one of 45.56±2.85%. Pont analysis for conventional methods was 39.35±0.04 mm and 49.17±2.55 mm, while for iModelAnalysis it was 39.35±0.07 mm and 49.19±2.57mm. The mean of the duration of analysis using conventional methods was 1703.81±56.46 seconds, while for iModelAnalysis it was 990.06±34.87 seconds. A normality test confirmed that the data was normally distributed (p>0.05). The results of a paired sample t-test with p>0.05 showed that there was no significant difference between the results of each analysis, while there was significant difference in the time period of analysis.* ***Conclusion:*** *There was no difference in the analysis results. However, there was difference in the time period of analysis between conventional methods and that of iModelAnalysis.*

Keywords: *conventional; iModelAnalysis; result of analysis; time period of analysis*

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INTRODUCTION

Study model analysis has been the gold standard for diagnostic procedures and dental treatment for many years. Various methods have been used for measuring and analyzing plaster models as study models, including calipers, rulers and other measuring tools. The data from the measurement was subsequently calculated to relevant formulas to produce the results of the analysis.[1] In the modern era, the use of electronic devices such as smartphones and tablets, often referred to as gadgets, is increasing because they are extremely portable. This consistent development has also been observed by healthcare practitioners active in the orthodontic field. Many applications for tooth ratio calculations within model analysis are available on Google Play Store for Android and Apple's App Store for iOS to facilitate treatment for both dentists and patients.[2,3] Over the last ten years, dental technology has developed considerably in the area of model analysis, for example in diagnosis using a digital model. Experts are developing computer-based analyzes that can simplify the work of dentists. Computer-based analyzes were employed to scan the model for analysis, but not to measure it. Although they may facilitate the practice of dentists, their use is rare because

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the devices are limited from the perspective of obtaining accurate results. Such devices for digital modelling are still being developed in order to obtain more accurate results and are only produced in limited numbers because of the difficulty and cost of doing so.[4]

Analysis of the study model was not only performed using conventional methods or computers utilising expensive digital models, but also by means of the applications available to dentists on smartphones or other portable electronic devices. One such application for performing model analysis available through Google Play Store and Apple's App Store is iModelAnalysis. This downloadable application is available free of charge and facilitates mathematical calculations of model study analysis.[5] According to *Mamillapalli et al. (2012)* who were its creators, iModelAnalysis performs mathematical calculations easily and accurately as part of model study analysis. Model analysis employing the conventional method is a relatively time-consuming process so the iModelAnalysis application is expected to be more efficient than conventional methods.[5] The purpose of this study was to obtain the differences in results and time periods of models analysis using conventional and iModelAnalysis.

MATERIALS AND METHODS

Before conducting the research, the authors applied for a permit to conduct research at the Orthodontics Laboratory of Padjadjaran University and a letter of approval from the Ethics Committee. These documents were required since the research employed dental casts constituting the personal data of patients. The letter of ethical exemption No:1248/UN6.C.10/PN/2017 contained the registration number 0217121360.

This research was comparative analytical in nature and conducted to identify any differences in terms of duration and results between model analysis adhering to conventional methods and iModelAnalysis application on smartphones. This research was conducted using a conventional study model whose inclusion and exclusion criteria were adopted when samples were collected (Figure 1A). The collected study model samples were measured using both conventional and iModelAnalysis methods. The inclusion criteria included: the gips model having fully erupted teeth from the first left molar to the first right molar (12 teeth on each jaw), none having been extracted from the 12 teeth in the study model, the study model being in a good condition without defects and the impression of the teeth anatomy being well-defined. The exclusion criteria comprised the study model having caries so severe that the crown structure was missing from the 12 teeth, anomalies in the teeth, and the gips model being fractured, broken or eroded. During the measuring process, random sampling was performed in an effort to reduce the error rate of measurement (error method). Based on the results of this study conducted in the Laboratory of Padjadjaran University on 31 pairs of Padjadjaran University Dentistry students of the study model class of 2014. Measurements were taken once for each analysis by one participant using a conventional method and iModelAnalysis, while the other assisted in the preparation of the study.

The tools and materials required for this research included study models, pencils or marker pens, calipers, rulers and paper on which to write the measurements taken, Android or Apple-based smartphones with an iModelAnalysis application and a stopwatch. The application named iModelAnalysis can be run on Android-based smartphones and iOS iPhones. The measurements of the model analysis to be performed included an Arch Length Discrepancy (ALD) analysis, Bolton analysis, Howes analysis and a Pont analysis. The analysis is frequently conducted in daily dental practice and forms part of dental college syllabi in Indonesia.

The duration of the count model analysis using conventional methods was recorded with a stopwatch. ALD analysis involves measuring the mesiodistal of each tooth with calipers starting from regio 1 on the study model provided and recording the measurements on paper. The teeth measured included 12 maxilla (16 -26) and 12 mandibles (36-46) (Figure 1B). The length of the jaw arch was subsequently measured by dividing the jaw into six segments each consisting of two teeth from the first right molar to the left first molar. The length of each segment was measured with the calipers and added together (Figure 1C). The results were then calculated by looking at the difference between the number of mesiodistal 12 teeth and the length of the jaw arch.[6]

Bolton analysis was conducted using calipers to measure the mesiodistal of the teeth in the same manner as that used to take ALD measurements starting from region 1 in the study model provided. The teeth measured were 12 maxilla (16-26) and 12 mandible (36-46). The measurement data was entered in the formula, the result calculated and then recorded.[6]

Howes analysis measured the mesiodistal of teeth 16-26 in the study model provided. The width of the jaw arch, the apical base diameter and the distance between the deepest point of the right and left right fossa (apex tip of the tooth 14-24) were measured from the forward direction of the tooth model using a caliper (Figure 1D), before the length was quantified. The measurement result was entered into the formula available and the result calculated. A record was kept of the analysis results obtained through the application of a Howes formula.[6]

Pont analysis measures the mesiodistal of four maxillary anterior teeth in the study model. The premolar region, the distance from the distal pit of upper right and left first premolar on the occlusal surface (Figure 1E) and the molar region and the distance from the mesial pit of upper right and left first molar on the occlusal surface (Figure 1F) were then measured with calipers. The width of the dental arch in the ideal premolar and molar region was calculated by using the Pont formula. The stopwatch was stopped and

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the time required to get the results of the analysis using conventional methods recorded.[6]

A model analysis using an iModelAnalysis commenced with the recording of the time using a stopwatch. This model analysis does not need to include measurement results in the analytical formula as it features an automated system for calculating the analysis. Firstly, the mesiodistal of each tooth starting from 12 teeth of the maxilla (16-26) and 12 teeth of the mandible (36-46) was measured using calipers. The measurements were inputted in the iModelAnalysis application to process the results of the analysis (Figure 2).[5]

The ALD calculation results were obtained after measuring the amount of available space in the jaw or the length of the jaw arch by means of an iModelAnalysis. Bolton's analysis of the results will be obtained after the data relating to the 12 teeth of the maxilla and the 12 teeth of the mandible are inputed into the iModelAnalysis. A Howes analysis measured the distance between the deepest point of the right and left right fossa (apex tip of teeth 14-24) and the distance between the buccal tops of teeth 14-24 measured from the occlusal direction. The Pont analysis calculation was performed by including the width of the first upper premolar (14 to 24) in the distal pit and the width between the maxillary first molars (16 to 26) in the mesial pit region. The stopwatch was stopped and the time required to obtain the results of the analysis using iModelAnalysis recorded. All data obtained was subsequently subjected to normality and paired t-test tests using "Statistical Package for the Social Sciences of International Business Machines" or a IBM SPSS Statistics version 20 program developed at the International Business Machine Corperation (IBM Corperation) Office New York, USA in 2016. A Kolmogorov Smirnov normality test with a significance level equal to 0.05 with $p>0.05$. The data was normally distributed and homogen with $p>0.05$ leading to the conducting of a parameter test, specifically a paired t-test, intended to determine whether the mean value of the data was statistically different.

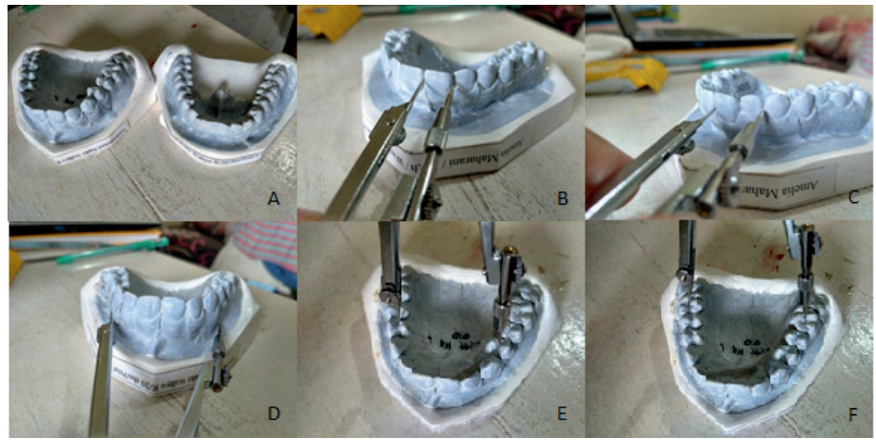

Figure 1. A) One of the study models for this research, B) the conventional method of measuring tooth dimensions C) measuring a segment of the arch during ALD analysis, D) measuring the apical base for Howes analysis, E) measuring the premolar regio during Pont analysis and F) measuring the molar regio during Pont analysis

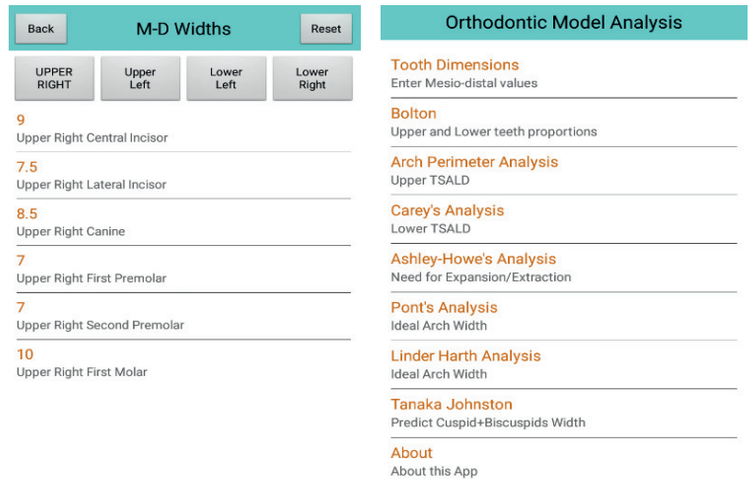

Figure 2. The measurement of the model study inputed in iModelAnalysis application and the orthodontic model analysis in iModelAnalysis.

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RESULTS

All data obtained from the research confirmed its normal distribution with p>0.05 indicating that it was spread evenly when the amount of data above and below the mean or average was equal. Once the average difference of two groups within the same sample had been established, a t-test of paired data with a significance level of 0.05 with p>0.05 was conducted.

Objectively, measuring the results of analysis did not show any significant differences, while for the period of analysis there was a significant difference between conventional methods and iModelAnalysis (Table 1). Data probability values were, above all, more than 0.05 (p>0.05), signifying that the data was evenly spread and that the existing sample can represent the actual population (Table 2). After confirming that the data was normally distributed (p>0.05), a parameter test was performed using a paired sample t-test. The results of a paired sample t-test with p>0.05 showed that all analyses indicated no significant difference of results between conventional methods and an iModelAnalysis. In contrast, there was a significant period of analysis between conventional methods and iModelAnalysis where the working time of the latter was shorter (Table 3).

DISCUSSION

Model analysis is an important step because it is one source of information in conducting an orthodontic diagnosis. A complete, clear and accurate diagnosis will determine the comprehensiveness of the treatment plan capable of maximizing the success of the orthodontic treatment undertaken. In addition to the study model, the analysis also utilizes other tools, such as measuring tools, radiographic features and approximate tables. Analysis can be performed either manually or using a digital system each of which has both advantages and disadvantages. Analyses of the study model varied, but one was selected according to its applicability to the experiences of the patient.[6]

The results of the analysis model showed no significant difference between the conventional and iModelAnalysis methods. The average results of the Bolton analysis conducted for this study showed an ideal overbite and overjet relationship which optimised the anterior ratio and total ratio. This result was related to the statement from premkumar that the ideal values are 77.2% ± 1.65 in anterior ratios and 91.3% ± 1.91 in the total ratio.[7] Other devices

Table 1. The mean of all analysis and time period between conventional method and iModelAnalysis on the smartphone.

Results	Mean ± SD	
	Conventional	iModelAnalysis
ALD analysis in maxilla	1.635 ± 2.636 mm	1.652 ± 2.432 mm
ALD analysis in mandible	1.374 ± 3.073 mm	1.416 ± 3.046 mm
Bolton analysis in anterior ratio	78.048 ± 2.698 %	77.910 ± 2.706%
Bolton analysis in total ratio	91.929 ± 1.297 %	91.961 ± 2.135%
Howes analysis	45.558 ± 2.839 %	45.561 ± 2.853%
Pont analysis in premolar	39.345 ± 0.045 mm	39.348 ± 0.071mm
Pont analysis in molar	49.174 ± 2.557 mm	49.190± 2.572 mm
Time period of the analysis	1703.81 ± 56.464 s	990.06 ± 34.870 s

Table 2. Normality test results

Kolmogorov Smirnov Z	Conventional	iModelAnalysis
Sig. of ALD analysis in maxilla	0.331	0.235
Sig. of ALD analysis in madible	0.388	0.438
Sig. of Bolton analysis in anterior ratio	0.492	0.224
Sig. of Bolton analysis in anterior ratio	0.478	0.902
Sig. of Howes analysis	0.986	0.999
Sig. of Pont analysis in premolar regio	0.629	0.680
Sig. of Pont analysis in molar regio	0.567	0.777
Sig. of time period of the analysis	0.951	0.898

Sig: probability

Sig p > 0.05

Table 3. The results of paired data t-test.

	Df	Sig. 2 tailed	t hit.	t tab.
ALD analysis in maxilla	29	0.604	-0.525	2.045
ALD analysis in mandible	29	0.434	-0.787	2.045
Bolton analysis in anterior ratio	29	0.269	1.125	2.045
Bolton analysis in total ratio	29	0.843	-0.199	2.045
Howes analysis	29	0.059	1.962	2.045
Pont analysis in premolar regio	29	0.911	-0.112	2.045
Pont analysis in molar regio	29	0.950	0.062	2.045
Time period of analysis	29	0.000*	66.639	2.045

*significant if p < 0.05
df = degree of freedom
Sig. 2 tailed = the probability of paired data t-test
t hit = t count
t tab. = t table
Sig p > 0.05

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that can be used to accurately conduct a Pont analysis in addition to an iModelAnalysis are the laser assembly scanners at the Department of Orthodontics of the Faculty of Dentistry at the University of Indonesia and at the School of Electrical Engineering and Informatics at the Bandung Institute of Technology used for the measurement and analysis of the upper transverse dental arch using a Pont analysis 3-dimensional digital model study case of medium to heavy dental teeth.[8]

The results of this study matched the opinion of Singh (2013) who was seeking a wide range of applications available to practitioners and orthodontic patients on four types of smartphones. The search results confirmed the existence of 32 orthodontics-related applications which can be downloaded from Android and 57 applications that can be downloaded from Apple. A number of these applications provide invalid and unsupported information, while only some have been recognized such as Bolton Calc, Carriere Ortho 3D, FAQ fix, iModelAnalysis which align on time. ImodelAnalysis was rated at 4.5 out of 5 by users because it provides an easy-to-execute model analysis.[3]

Overall, digital models have been widely used for diagnostic purposes either by using a plaster model or directly involving the patient in question. The respective accuracy of measurements taken using digital and plaster models remains a frequently-researched issue.[4] Other research provides a systematic review of comparisons between digital model measurements and those taken by measuring instruments on plaster models. Seven digital model systems are used in Fleming research, namely: OrthoCad, emodel, C3D-builder, ConoProbe, Easy3D Scan, Digimodels and Cecile. The results of this study state that "digital models offer the same level of validity as compared with direct measurements on the plaster model, but the quality of the difference in outcomes is clinically acceptable, due to inadequate samples, and standard errors due to different techniques."[9] (2011:14)

The results of a hypothesis test comparing all the calculations of a study model analysis of conventional methods with an iModelAnalysis on smartphones using paired data t-test showed no statistically significant difference. The main factor in performing model analysis is the different form of measurement. Measurement by conventional methods involves the use of calipers and committing the results to paper before the overall amount is quantified. In contrast, iModelAnalysis measures all data inputted, produces the measurements directly and then calculates the results. The differences in model analysis using conventional methods should be calculated using the existing formula for each analysis, whereas iModelAnalysis-generated calculation results will be produced automatically when the data inputted.[4]

Factors such as the ability and experience of the researcher in performing measurements contribute to the emergence of differences when comparing the two methods of measurement model analysis.[10] Competent researchers will provide more accurate results compared to their counterparts lacking experience. Another factor evident in performing model analysis consists of the tools and methods employed. Contemporary highly developed computer-based applications or systems and tools utilize digital tools.[10] The digital analysis conducted by Wan Hassan et al. found no statistically significant differences between methods and operators. Bland-Altman plots showed that the mean biases were close to zero, while 95% of the limits of agreement were within 0.50 mm.[11] Leifert also conducted a study using OrthoCAD which compared space analysis results by means of a digital model with conventional gypsum models. This research yielded a slightly significant difference (0.4 mm) in spatial analysis for the maxillary model and no significant difference in the mandibular model between the digital and gypsum models. The accuracy of the digital model produced by OrthoCAD software is clinically acceptable for the evaluation of space analysis.[12]

One study argued that the digital measurements obtained from study models produced by OrthoProof® (CBCT-Imaging) systems and DigiModel software are as accurate as those obtained manually through traditional study models.[1] Although computerized model analyzes have evolved up to the present, conventional model analysis is still commonly conducted by orthodontic practitioners because it involves the use of simple, accessible and affordable tools such as symmetographs, manual calipers with sharp edges, rulers, digital calipers and a sliding range. Data storage systems are generally still performed manually, while the study model is stored in a tailor-made storage facility.[13,14]

The ever-increasing number of tools and devices devised and developed are expected to be readily applicable to model analysis, providing accurate results. Nevertheless, given the proliferation of tools and devices created for model analysis, examination of their accuracy is ongoing.[14,15]

The times taken to conduct an analysis using each method show that the average period of analysis using the conventional method is 1703.81 seconds or about 28 minutes 24 seconds and the average working time using iModelAnalysis is 990.06 seconds or about 16 minutes 30 seconds. The result of a hypothesis test shows that there is a significant difference in the time period of analysis between a conventional method and iModelAnalysis whose working time is shorter.

The results of this research show no difference in the model analysis calculation result between conventional methods and an iModelAnalysis using a smartphone. However, there was a significant difference in the time period of analysis between the conventional method and the smartphone-based iModelAnalysis. The data confirmed that this iModelAnalysis application provides accurate results more quickly and efficiently. The significant time difference between conventional methods and iModelAnalysis can occur because in model analysis, two tasks must be undertaken, namely; measurement and calculation. The conventional method of model analysis

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involves initial measurement followed by calculation of the result through application of the formula for each analysis. Since iModelAnalysis requires only the measurement results which exit automatically from its system, this results in more rapid processing.[4,14] This conclusion matches that of Gupta and Vaid (2017) which states that of the various existing smartphone applications available to orthodontic practitioners the most appropriate is iModelAnalysis because it facilitates the mathematical calculation of results from model analysis and renders research more efficient.[2]

It concluded that no difference exists between the analysis results of conventional methods and iModelAnalysis so that the application of the latter can be used in calculating model analysis and producing a result equal to that of conventional methods. However, the respective duration of analysis in conventional methods and iModelAnalysis provides a difference, the time required in for iModelAnalysis is much shorter than analysis by conventional methods, rendering it more efficient. Recommendations for further research include calculations being produced more than once. Undertaking calculations twice or three times in one model analysis should ensure that the results produced are unbiased and more accurate.

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