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COMPARISON OF MANUAL, DIGITAL, AND AI MEASUREMENT IN THE DIAGNOSIS OF MANDIBULAR ASYMMETRY

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ABSTRACT

Background: Mandibular asymmetry is one of the widespread conditions that affects many of the individuals. Accurate diagnosis and treatment are needed for this illness. Aim: The aim of this study is to compare mandibular asymmetry using manual, digital, and AI methods. Methods: From March to April 2025, a cross-sectional study was analysed in the Orthodontic Specialist Clinic of the Dental Hospital Faculty of Dentistry, Universitas Indonesia. This research included 15 patients who were diagnosed with mandibular asymmetry and not undergone orthodontic treatment. This study examines diagnosing asymmetry in six different facial features, including the Co-Ag, Co-Me, Ag-Me, Angle of Ag, JMSR, and AgMSR. Results: This study confirms that there was no specific difference between the measurement angle of Ag. Scientists have used a paired t-test to compare the p-value, which was greater than 0.05. The Kappa Cohen analysis was used to analyse the strength of agreement of each parameter. Conclusion: This research highlights that manual, AI and digital methods are similarly effective for measuring the angle of Ag for the treatment of mandibular asymmetry. This study may be helpful for orthodontists in treating and diagnosing mandibular asymmetry.

KEYWORDS: Mandibular Asymmetry, Kappa Cohen Analysis, Image Processing Methods, Manual Methods.

1. INTRODUCTION

Mandibular asymmetry is a common disorder in individuals, which also includes a variation in the mandible size or location in relation to the maxilla (top jaw). Agurto-Sanhueza et al., 2025 discussed that this disorder may affect all shades, and it might be increasing dysonic, which increases both functional and aesthetic areas. This mandibular asymmetry includes more complex factors, which consist of genetic susceptibility, developmental disorders, trauma, and pathology (Stăncioiu et al., 2025). This accurate diagnosis of mandicular asymmetry will obtain a proper etiology and effective treatments for patients in future (Bor et al., 2025). On previous research (Liu et al., 2023) discussed that mandibular asymmetry has particularly leaned on manual analysis, wereas orthodontists and dental practitioners treat the properties of the face in terms of calliper and ruler measurements. Accessibility and simplicity are one of the main advantages of manual methods (Liu et al., 2023). Nevertheless, they have some disadvantages, such as subjective interpretation, human mistakes, and distinct methods may provide different results. Tomášik et al. 2024 discussed that digital technologies will increase the precision of measurements in orthodontics. Additionally, these image processing methods will help to detect the features of the face with precision and repeatability, and it is also detecting facial features accurately using digital imaging data (Jiménez-Gayosso et al., 2018).

Recent development in the artificial intelligence (AI) provides a new way for diagnosing mandibular asymmetry. Artificial or image processing methods will be helpful in detecting the large amount of data and information which cannot be seen by the human eye. These AI methods will analyze the measurements and facial features, and this method will reduce human error (Ileșan et al., 2023).

Digital methods have been increasingly implemented in orthodontic field. The research should be held on comparing both the manual orthodontic diagnosis methods with AI-based approaches (Ahn et al., 2024). This study fills the gap between the cross-sectional and observational analysis of mandibular asymmetry diagnosis using three different methods such as AI, manual, and digital methods. Specifically, six key facial features essential for measuring mandibular symmetry will be considered: Co-Ag (Condylion to A-point), Co-Me (Condylion to Menton), Ag-Me (A-point to Menton), the Angle of Ag (Angle at A-point), the Maximum Symmetry Ratio by Jayaraman (JMSR), and the Maximum Symmetry Ratio by Ag (AgMSR). This complex approach has used to analyse the strengths and weaknesses of each methodology. This study provides insights for dental practitioners by comparing digital, manual and AI approaches.

In recent years, AI in orthodontics has changed its role. The craniofacial structure visualization and interpretation have been enhanced by the use of digital imaging systems, cephalometric analysis and cone-beam computed tomography (CBCT). These methods can elaborate 3D patient reconstructions in more detail than conventional two-dimensional techniques, thus providing a more comprehensive picture. However, errors remain in the best ways to implement such technologies in clinical practice, even with these improvements. Machine learning algorithms have shown great promise in the field of artificial intelligence. Such algorithms can learn on a scale of large volumes, which gives them more time and enhances the quality of patient evaluation as time goes by. The opportunities of AI in orthodontics are enormous, as they can potentially replace manual cephalometric analysis and forecast intervention results based on previous records. Nevertheless, the practical use of these technologies requires heavy authentication to ascertain that they meet clinical standards. The methodology of the current study presupposes the examination of facial features through three steps: measures calculated with the help of manual tools by professional clinicians, calculation of the measures through digital tools, and analysis of measures provided by an AI system. Using strong statistical analysis, paired t-tests, and Cohen's kappa analysis, this study attempted to provide a straightforward understanding of the consistency and disagreements in these methods. This study also explores other important measurements of the face that lead Japanese doctors to arrive at the diagnosis of the mandibular asymmetry, since the angle of Ag scene is an important aspect, much needed when it comes to diagnosing the problem.

This study will examine the advantages and disadvantages of both traditional and advanced methods. This research will be helpful to evaluate the precise diagnosis for orthodontics. The advancement in orthodontics is mainly focused on accurate and precise measurements for the diagnosis of mandibular asymmetry (Vernucci et al., 2019). This research will be helpful for the orthodontic community to analyse the forms of measurement in manual, digital, and AI-based methods. This study will be useful for practitioners to take accurate decisions in choosing diagnostic methodologies. The main aim of this study is to enhance the patients' health with right treatment and diagnosis for mandibular asymmetry. This research not only focuses on treating orthodontics, but it also emphasises the significance of incorporating technological advances in dental treatment and procedures.

2. METHODS

A cross- sectional approach was held on this analytical observational study. The clinical procedure of this research is conducted on Dental Hospital of the Faculty of Dentistry, Universitas Indonesia in March - April 2025. This study was conducted using the patients with dentocraniofacial asymmetry in the orthodontic treatment at the RSKGM FKG UI Orthodontic Specialist Clinic in 2025. Scientists have used 15 people to be sampled based on Dahlan formula (2010).

The study was confirmed by the Dental Research Ethics Committee, Faculty of Dentistry, Universitas Indonesia with Protocol no: 050180223, approved on February 12th, 2025. This study includes all the written informed consent to all the participants. The clinical examinations were done carefully by standardized procedures to confirm the accuracy and reliability of the collected data. By carefully evaluating patients dentocraniofacial characteristics, the researchers were able to learn important details about the type of asymmetry that existed in the study group. A complete assessment of dentocraniofacial structures was analysed by each participant which can be helpful for the researchers to gather more valuable insights. To process the data, a systematic comparative analysis and hypothesis test was conducted to analyse the proportion between dependent variables, namely with paired T-Test to detect the difference in each parameter measurement including CoAg, CoMe, AgMe, angle of Ag, JSMR, and AgMSR, the results of the diagnosis of dentocraniofacial symmetry. Kappa Cohen's analysis was used to detect the level of agreement between 2D and 3D diagnostic approach for dentocraniofacial symmetry across all parameters.

3. RESULTS

A comparative test was undergone with paired t Test to see if there was a difference in the measurement of each parameter in the diagnosis of dentocraniofacial symmetry.

Table 1: Coag Measurements.

Condition	Manual	WinCeph	WebCeph	p-value	Reliability (95% CI)
CoAg Deviated	72.44 ± 4.95	78.48 ± 10.55	63.79 ± 7.71	0.001*	Manual & WinCeph: 0.499 (−0.199 – 0.812) Manual & WebCeph: 0.424 (−0.262 – 0.785)
CoAg Non-Deviated	75.06 ± 7.29	81.42 ± 10.86	65.19 ± 7.78	0.001*	Manual & WinCeph: 0.830 (−0.112 – 0.958) Manual & WebCeph: 0.580 (−0.211 – 0.880)

The comparative analysis of CoAg (Condylion-A to Gnathion) measures calculated using three different techniques, namely Manual, WinCeph, and WebCeph, in the deviated and non-deviated situations is shown in Table 1. The findings have shown statistically significant results between the three methods (p = 0.001). Compared to WinCeph and WebCeph, the reliability of the manual measures is moderate, as illustrated by the assessments of intraclass correlation coefficients (ICCs) within the 95% confidence interval. WebCeph was more likely to vary in the interpretation of CoAg parameters than was reflected in overall agreement between the medical performance using the manual and software-based methods. Thus, the variability indicates that WinCeph and WebCeph may exhibit a difference in the interpretation.

Table 2: Come Measurements.

Condition	Manual	WinCeph	WebCeph	p-value	Reliability (95% CI)
CoMe Deviated	115.19 ± 8.45	128.79 ± 15.13	99.94 ± 11.93	0.001*	Manual & WinCeph: 0.390 (−0.278 – 0.757) Manual & WebCeph: 0.454 (−0.237 – 0.811)
CoMe non-deviated	117.37 ± 11.02	133.97 ± 14.69	101.94 ± 12.41	0.001*	Manual & WinCeph: 0.579 (−0.228 – 0.877) Manual & WebCeph: 0.560 (−0.228 – 0.868)

Table 2 provides a summary of the CoMe (Condylion-Menton) of the deviated and non-deviated groups of Manual, WinCeph, and WebCeph. The three measurement techniques showed considerable variance (p = 0.001*); thus, landmark identification or measurement scale differences may exist between platforms. The reliability analysis showed moderate consistency between the FEC and the two digital tracing systems, with ICC values ranging from 0.39 to 0.58. These results are quite indicative that it is possible to conduct CoMe estimation in all three methods, but it does not mean that manual and digital methods can be used interchangeably.

Table 3: Agme, Sudutag, JMSR, And Agmsr Measurements.

Condition	Manual	WinCeph	WebCeph	p-value	Reliability (95% CI)
AgMe Deviated	55.87 ± 6.14	61.62 ± 7.83	47.14 ± 5.38	0.001*	Manual & WinCeph: 0.781 (−0.191 – 0.945) Manual & WebCeph: 0.541 (−0.156 – 0.867)
AgMe Non-Deviated	61.12 ± 11.01	67.79 ± 9.06	48.06 ± 5.90	0.001*	Manual & WinCeph: 0.865 (−0.139 – 0.970) Manual & WebCeph: 0.536 (−0.179 – 0.862)
SudutAg Deviated	131.87 ± 6.50	132.37 ± 7.31	128.02 ± 5.60	0.856	Manual & WinCeph: 0.800 (0.417 – 0.930) Manual & WebCeph: 0.003* (0.086 – 0.942)
SudutAg Non-Deviated	129.31 ± 6.68	128.75 ± 6.14	127.42 ± 5.66	0.605	Manual & WinCeph: 0.881 (0.661 – 0.959) Manual & WebCeph: 0.095 (0.576 – 0.948)
JMSR Deviated	34.75 ± 2.93	38.77 ± 3.88	31.23 ± 2.88	0.001*	Manual & WinCeph: 0.642 (−0.217 – 0.903) Manual & WebCeph: 0.675 (−0.140 – 0.920)
JMSR Non-Deviated	33.19 ± 1.17	38.79 ± 4.57	30.89 ± 2.82	0.001*	Manual & WinCeph: −0.033 (−0.432 – 0.425) Manual & WebCeph: 0.011* (−0.009 – 0.549)
AgMSR Deviated	49.44 ± 4.40	56.23 ± 5.04	41.80 ± 4.40	0.001*	Manual & WinCeph: 0.580 (−0.146 – 0.885) Manual & WebCeph: 0.477 (−0.129 – 0.838)
AgMSR Non-Deviated	47.69 ± 7.32	52.29 ± 6.77	40.09 ± 4.61	0.001*	Manual & WinCeph: 0.880 (−0.128 – 0.975) Manual & WebCeph: 0.637 (−0.183 – 0.904)

The findings of the various cephalometric parameters (AgMe, SudutAg, JMSR, and AgMSR) in both scenarios (deviated and non-deviated) using Manual, WinCeph, and WebCeph approaches are detailed in Table 3. Most of the variables, except SudutAg, showed significant differences (p = 0.001) with no statistically significant difference between methods. The reliability scores (95% CI) varied across different parameters of the study, resulting in varying levels of agreement between manual and digital methods. Overall, WinCeph and WebCeph provided similar results in some measurements, but manual analysis is considered more valid as a standard of reference.

The test results with p<0.05 with all parameters measures the significant difference between the manual, digital and AI based approach except the measurement angle of Ag. 15 samples have been acquired in the form of DICOM CBCT are designed using a software called Carestream 3D Imaging v3.87 and it redefined the posteroanterior cephalogram image on a 168.3 mm image slice. This is in line with research conducted by Kumar (2007) and Robben et al. (2017), which states that the reconstruction of two-dimensional cephalogram images from CBCT imaging results can provide an image like conventional cephalogram results with linear and angular size accuracy and the same precision. Findings says that posteroanterior cephalogram reconstructed image will analyse the dentocraniofacial symmetry using the software. Research by Meldenik et al. (2011) stated that the use of Carestream 3D imaging can provide good contrast and resolution as well as good accuracy during the analysis process, which can affect visualization in determining craniometric points. This study used the Grummon technique to measure the linear differences between each side and the midsagittal reference line between 15 parameters. The distance and the single parameter point of the midsagittal reference line was measured. If the linear discrepancy value obtained was more than two millimeters, a diagnosis of asymmetry was made (Katsumata et al., 2005).

The 3D study was performed on 15 CBCT samples through multiplanar reconstruction and volumetric rendering. Barreto et al. (2020), states that cephalometric measurements in multiplanar reconstruction have strong accuracy and angular measurements. The analysis process is carried out by measuring each parameter using digital analysis (WinCeph) and AI-based analysis (WebCeph). The asymmetry measurement obtained will be compared with the manual measurement index. The results of the paired t-test on all parameters showed a p-value < 0.05, meaning that there was a significant difference between all parameters except the measurement of the angle of Ag. Kappa Cohen analysis was undergone to assess the agreement of each parameter. The highest agreement value was viewed in the parameters of the angle of Ag.

Systematic errors and random errors are the two types of cephalometric analysis errors. To reduce magnification and distortion CBCT imaging was performed. To minimize the systematic errors (Carestream 3D Imaging v3.87) software has been used and the 2D images was redesigned from CBCT data.

The study measurements were performed by one researcher (SS) with clear operational definitions so that, according to Lisboa et al. (2014), systematic errors in craniometric point identification do not affect the results of the study if supported by a good intrarater reliability assessment.

The second error is called as Random error. This error has a different measurement data due to difficulty in measurement. Random errors can often occur in a measurement of cephalometric analysis due to imprecise craniometric point placement. Many factors, such as image brightness, contrast settings and operation fatigue can impact the accuracy of craniometric point placement. Scientists used suitable brightness and contrast settings to prevent fatigue.

Some craniometric points are difficult to identify in both two and three dimensions, and researchers' opinions on the accurate positioning of craniometric points may vary (Medelnik et al., 2011). Along with defined parameter points, identifying the most anterior/posterior/inferior in areas such as orbit or gonion has high subjectivity. Oliveira et al., 2009 discussed that placing condyle point become more difficult due to its curved anatomical structure and lack of complete information. Vlijmen et al. (2010) also added that differences in diagnosis results between digital methods can occur due to the addition of shadow images that can affect the diagnosis. In AI-based analysis, anatomical structures can be observed automatically (Chien et al., 2009). This identification difficulty in craniometric points also affects the determination of the reference sagittal plane in both manual and digital methods (de Oliveira et al., 2009). In manual and digital methods, central line is explained using the midsagittal reference, wereas in AI methods central line is detected automatically. Identifying the sella point on a 2D posteroanterior cephalogram image is impossible due to frontal superimposition, and cause variations in transverse measurements, significantly in MSR values. The sella point located at the skull base grows small after the age of five, towards the inferior anterior direction. The nasion point becomes more stable with no transverse direction. The frontal part of the cranial base becomes more stable after age of seven, making it a good reference plane. This investigation states that both the manual and digital analysis is difficult to identify the craniometric points. Midsagital points from the crest galli is observed by both the manual and digital methods in central reference line. The central plane is observed by using sella and nasion reference points automatically in AI based methods. It is difficult to detect the sella point on a manual and digital posterioanterior cephalogram image, because anatomical features of the frontal directions are superimposed. This study reveals the difference of manual, digital, and AI methods in transverse size values.

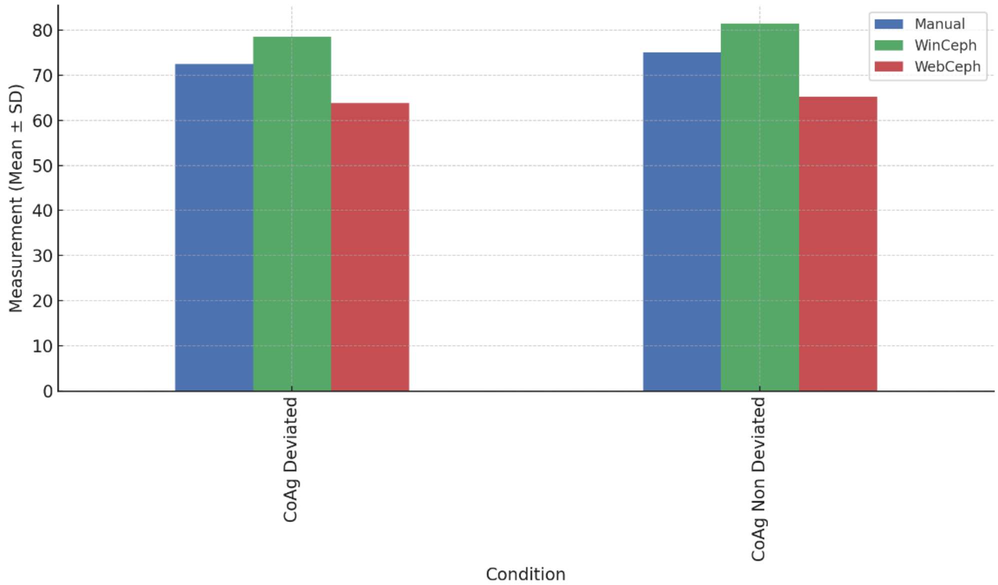

Figure 1: Comparison Of Manual, Winceph, And Webceph Measurements for Coag Under Deviated and Non-Deviated Conditions.

Figure 1 represents a comparison of CoAg values measured using the Manual method, WinCeph method, and WebCeph in Deviated and Non-Deviated conditions. The results show that the WinCeph method had higher mean values compared to the Manual method, while WebCeph had lower mean values. The significant p-value (0.001*) indicates a statistically significant difference between the three measurement techniques, suggesting variations in accuracy and consistency among the methods.

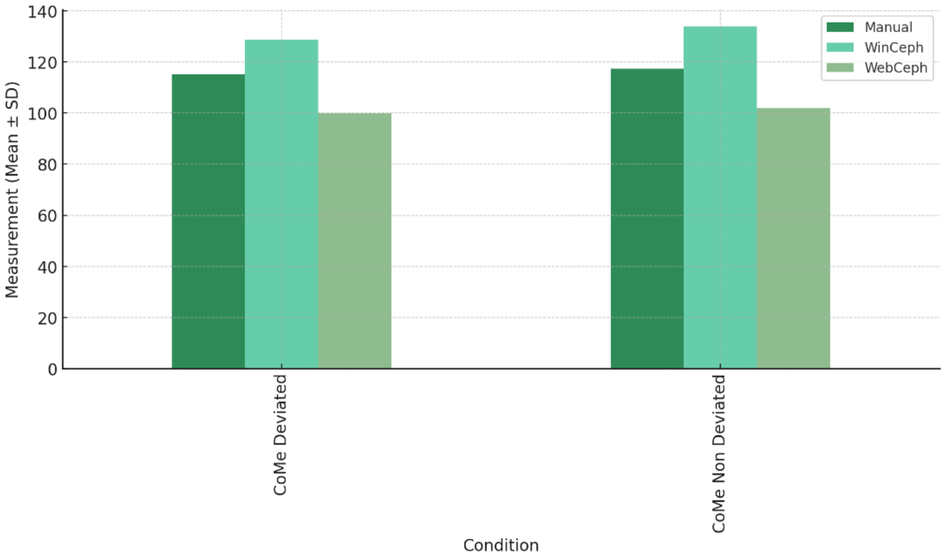

Figure 2: Comparison Of Manual, Winceph, And Webceph Measurements for Come Under Deviated and Non-Deviated Conditions.

In Figure 2, CoMe results in Deviated and Non-Deviated conditions are displayed on Manual, WinCeph, and WebCeph. Like Figure 1, the values of WinCeph are higher with lower values of WebCeph. The similarity in statistical significance ($p = 0.001^*$) shows that the difference among the three methods is not accidental. The reliability results indicate moderate consistency between the softwares and Manual measurements, and it needs further discussion whether automated systems are effective, or whether it is crucial to verify the accuracy by manual calculation.

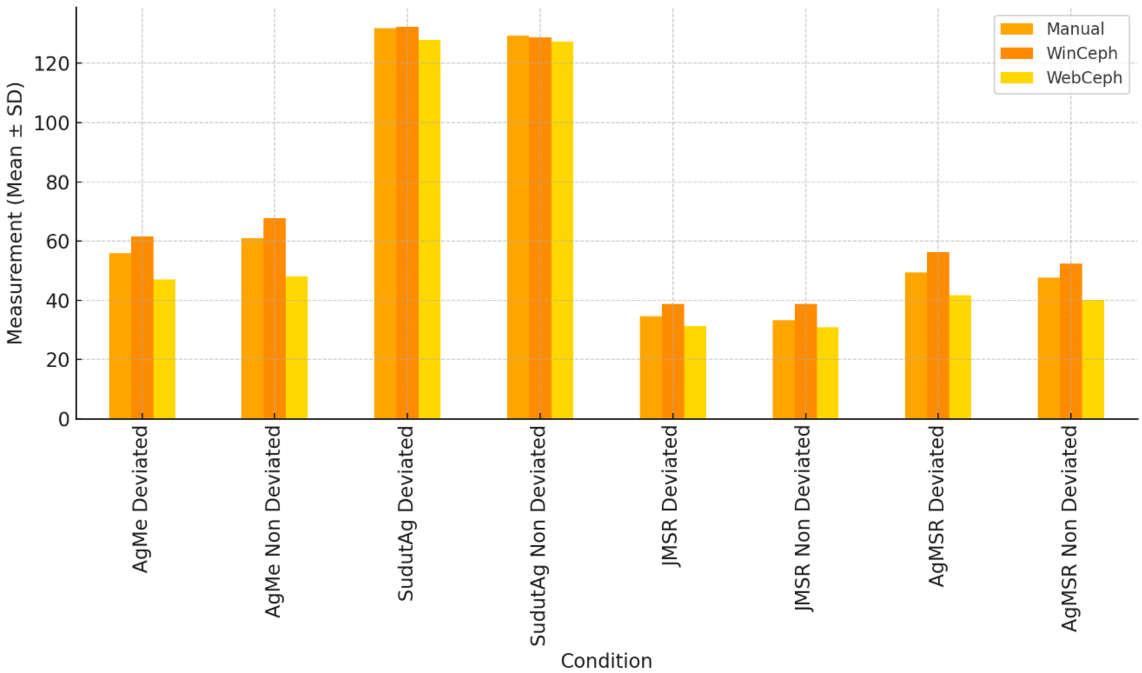

Figure 3: Comparison Of Manual, Winceph, And Webceph Measurements for Agme, Sudutag, JMSR, And Agmsr Under Deviated and Non-Deviated Conditions.

Figure 3 provides a comparison of the measurements of AgMe, SudutAg, JMSR and AgMSR in Deviated and Non-Deviated conditions of Manual, WinCeph and WebCeph measures. The statistics demonstrated differences in measurement uniformity among the various anatomical parameters, with WinCeph tending to have better average scores and WebCeph having lower average scores. Although there are only slight changes in certain parameters as illustrated by SudutAg, significant changes are found in others like AgMe, JMSR, and AgMSR ($p = 0.001$), which is to argue that caution in the use of digital cephalometric analysis tools is necessary.

This study found more consistent angle Ag measurements on manual, digital, and AI methods, it may be varied in all parameters between 2D and 3D diagnostic results. Manual, digital, and AI-based methods will be helpful for orthodontists to analyse the dentocraniofacial structure in depth by the translational or a combination of rolling, yawing, and pitching that can affect the treatment plan. According to Ko et al., 2022 states that optimal treatment in asymmetry patients' needs a comprehensive dentocraniofacial evaluation in outer and inner dentoskeletal components, using 3D CBCT.

4. CONCLUSION

This study examined the variations in dental measurements, subject to three different methods, namely, Manual, WinCeph, and WebCeph, under diverse clinical situations, CoAg (Coordination Agility), CoMe (Coordination Measured), AgMe (Angular Measurement), SudutAg (Angular Measurements), JMSR (Jaw Movement Spatial Relations), and AgMSR (Angular jaw Movement Spatial Relations) in cases of deviation and non-deviation. The comparison indicates the important differences ($p < 0.05$), specifically between the Manual and WinCeph and Manual and WebCeph techniques for conducting CoAg and CoMe measurements, indicating that the measuring methodological activity that is applied can result in significant changes in the values attained. These results explore the importance of selected methodology for clinical assessments, which can make a difference in methods of diagnosis and treatment. Reliability analysis using 95% confidence intervals showed that some approaches, such as Manual and WinCeph, showed an outstanding degree of reliability (>0.80), while WebCeph measurements, in general, and across different conditions, had a tendency to represent moderate to low reliability (<0.60). This investigation will be useful for the practitioners to choose the right approach of measurements, but it is important to inform the calibration and constancy to practicioners before using clinical practices. Additionally, these findings indicates that practitioners need to be more aware of methodological differences, so they can utilize appropriate measurements that impact patient outcomes. This study states that effective procedure of measurements is needed in medical context to develop better diagnosis and treatment outcome. Further investigation is needed to define the fundamental causes of the delays which is seen in various measurement methods. More research is needed on enhancing the measurement reliability, demographic factors, development of calibration process, and expand the sample size. This investigation help practitioners to choose right measurement procedures with developed reliability to high-quality patient assessment. This analysis ends by the statement that careful selection and justification of measurement methods are needed to develop the right clinical analysis, and still, it has effectiveness of dental treatment and patient satisfaction. Dental treatment and patient outcome in dental practices can better be achieved as dental community through continuous research and improving methods will determine the process of making clinical measures more dependable, thus aiding clinical procedures and yielding better results.

4.1. Ethics And Consent

The clinical examination of the research subjects was carried out at the Dental Hospital of the Faculty of Dentistry, University of Indonesia in March - April 2023.

The study was approved by the Dental Research Ethics Committee, Faculty of Dentistry, Universitas Indonesia with (Protocol no: 050180223) has approved the study on February 12th, 2023. A written informed consent was obtained from all the participants.

4.2. Data Availability Statement

Underlying Data.xlsx. figshare. Dataset. https://doi.org/10.6084/m9.figshare.24331090.v1

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