Accuracy of mesiodistal teeth and dental arch width measurement with conventional plaster and digital model study

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Abstract

Objective: This study aims to determine the accuracy of the sum mesiodistal width and the arch width from the conventional plaster model, 2D digital scan, 3D intraoral scanning, and Cone Beam Computed Tomography (CBCT) methods.

Material and Methods: The type of research in this study is a comparative experimental conducted by comparing 5 different sample groups. The study was conducted on 5 study models in each group, the control group (typodont), and the treatment group (the conventional plaster model, 2D digital scan, 3D intraoral scanning, and CBCT). The parameters measured were the sum of mesiodistal width and inter premolar. Each measurement was repeated 3 times by the same observer, then averaged. Statistical analysis using Pearson correlation to determine the correlation between the accuracy of the measurement method compared to the control group (typodont).

Results: The results showed that there was a significant accuracy correlation (p<0.05) in measuring the sum of mesiodistal width and inter premolar between the control group (typodont) using conventional plaster model measurement methods, 2D digital scan, 3D intraoral scanning, and CBCT.

Conclusion: The conclusion of this study is conventional measurement methods, 2D digital scan, 3D intraoral scanning, and CBCT are accurate in measuring the sum of mesiodistal width and inter premolar width.

Keywords: Accuracy study models, Conventional plaster models, Digital study models, Three dimensional study models, Two-dimensional digital model scans

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Introduction

The successful of orthodontic treatment is determined by the accuracy of the diagnosis and treatment plan. Determination of orthodontic diagnosis requires of patient data, one of which is the form of patient data records, that is the study model. The study model obtained from the patient is used for analysis of the study model needed in diagnosis and treatment planning as well as for evaluation of treatment progress. The accuracy of measurement and calculation of the analysis of the study model is very important for determining the diagnosis and treatment plan. Measurement of the mesiodistal width of the tooth and the dental arch width are the necessary measurements in the analysis of the study model. Mesiodistal width measurements of the patient’s teeth and dental arch width need to be measured carefully so that a diagnosis and a patient’s treatment plan can be determined. The study model used in establishing the diagnosis can be in the form of a conventional model made from plaster or a digital study model that is currently being developed.

Material and Methods

The subject of this study is typodont with the criteria for complete permanent maxillary artificial teeth and had normal morphological conditions. The accuracy test was divided into 5 sample groups, namely group I is the typodont group (gold standard) with 5 samples, group II is a conventional plaster study model with 5 samples obtained from typodont printing, group III consisted of 5 digital 2D study models from plaster study model scans, group IV consisted of 5 digital 3D study models of typodont’s scans, and group V consisted of 5 CBCT digital study models of typodont.

Typodont artificial teeth were measured using a digital calliper. The artificial teeth from the upper right first molar to the upper left first molar were measured directly and the results were recorded. The result of direct measurement on typodont is considered as the true value (gold standard). The conventional study model was made manually by cast the typodont using alginate material. Imprinting is done on the upper jaw only. The results of the alginate impression are filled using gypsum stone. The procedure for making a digital study model is made from a conventional plaster model which is then scanned using a Canon Pixma E4110 scanner, the study model is surrounded by graphic paper for calibration. The scanning results are in the form of digital files with .jpg format then evaluated, and measured using CorelDraw X7 software. The procedure for making a digital intraoral scanning study model...
making a digital intraoral scanning study model was carried out by scanning the maxillary typodont directly using an intraoral scanner (Medit i-500) on each sample. The scanning results are in the form of digital files in .stl format. The results of the digital file are then extracted in the Meshmixer® software and measured digitally. The creation of a CBCT digital study model was carried out by performing 3D CBCT imaging on the typodont. The upper jaw of the typodont is placed at the level of the occlusal guidance of the CBCT (Orthopantomograph® OP300) machine.

The accuracy test was carried out by one observer. Direct measurements were carried out on each typodont 3 times and averaged to get a reference value. Some of the parameters measured were the sum of mesiodistal teeth width, inter premolar distance, and intermolar distance. The accuracy of the sum of mesiodistal width of the tooth is a measurement with correct and consistent results from the most mesial to distal point based on the anatomical shape of the tooth measured parallel to the occlusal/incisal tooth in the study model, compared to the measurement results on the typodont (gold standard). The inter premolar distance was calculated as the distance between the most distal edge of the mesial concave on the occlusal surface of the right and left first premolars.

Before conducting this research, ethical clearance was approved by the Health Ethical Research Committee of Gadjah Mada University (00617/KKEP/FKG-UGM/EC/2021). The data were statistically analysed using the Pearson Correlation. If the distribution of the data is consistent in each measurement method compared to typodont, it is said that the measurement method is accurate. The accuracy of the measurement method is seen from the correlation test value. A measurement method is said to be the most accurate if it has a p value < 0.05 and a correlation coefficient (R) that is closest to one (1).

### Table 1. Pearson Correlation test between methods and typodont

<table>
<thead>
<tr>
<th>Measurement Methods</th>
<th>Sum of mesiodistal width</th>
<th>Inter P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R value</td>
<td>p</td>
</tr>
<tr>
<td>Conventional Plaster</td>
<td>0.982</td>
<td>0.005*</td>
</tr>
<tr>
<td>Scan 2D</td>
<td>0.913</td>
<td>0.038*</td>
</tr>
<tr>
<td>IOS 3D</td>
<td>0.961</td>
<td>0.009*</td>
</tr>
<tr>
<td>CBCT</td>
<td>0.941</td>
<td>0.017*</td>
</tr>
</tbody>
</table>

*p<0.05

### Results

The results of the Pearson correlation test showed that the conventional plaster model, 2D digital scanning, 3D intraoral scanning and CBCT methods had a significant correlation with controls (P<0.05) in measuring mesiodistal width and inter premolar width. The results showed that the measurement of the mesiodistal number of conventional plaster models, 2D scans, 3D intraoral scanning, and CBCT had an R value >0.90 which means it has a very good level of accuracy table 1. The results of the study on the measurement of inter premolar width showed that the conventional plaster model, 3D intraoral scanning, and CBCT methods had very strong accuracy against typodont as a control group (R=0.90–1.00), while the 2D scan measurement method had strong accuracy against the control group. control (R=0.70–0.89).

### Discussion

The conventional plaster model measurement method has the highest accuracy value compared to other measurement methods in measuring mesiodistal width inter premolar width and intermolar width. The measurement of the plaster model was measured using the same digital calliper and the measurement method was similar to typodont as a control so that the measurement results of the control group were closely related to the measurements of the conventional plaster model. Thus showing a fairly accurate measurement result of the mesiodistal number and arch width measurement values. The shrinkage of the impression material and degradation of the plaster can cause a slight difference in measurement compared to typodont, but still has very good accuracy. The conventional study model has several disadvantages, namely it requires a special storage area so as not to be damaged so that the size and shape of the teeth remain accurate when needed for analysis of the study model.

Accuracy of calibration and determination of the mesiodistal point of the tooth is required in the measurement to obtain a measurement in the form of a line which is the width of the tooth being measured. Two digital models have disadvantage when the dental impression is converted into a 2D digital model, the convex structure of the tooth and the angle of the scan can affect the measurement of the study model and cause inaccurate measurements. The result from this study showed that 2D scan has the lowest of accuracy value (R=0.881) but still accurate. The accuracy of imaging an object depends on the angle and distance of the object, as well as the resolution of the camera. The digital image looks blurry, which means that spatially there is missing information, so that on a 2D scan the inter premolar area is not very clear to determine...
The 3D intraoral scanner measurement method in this study has a lower accuracy value than the conventional plaster method, but still has a very strong accuracy value in measuring the mesiodistal number of teeth and inter premolar width against the control (typodont). This is because the 3D intraoral scanner method has a confocal imaging technique which is a 3D intraoral scanning technique based on the principle of focusing and not focusing an image at a certain depth. This technology can detect the sharpness of the area of an object and calculate the distance of the object based on the focal length of the lens.

The three-dimensional model has many advantages over conventional plaster models in orthodontic aspects, including it is easier to share it with doctors or other professionals from anywhere for advice on treatment plans or diagnostics, easier to apply to patients who have gag reflex due to alginate and in patients who cannot open their mouths wide, 3D digital storage has no physical storage problems, as it doesn’t take up much space to store it over the years, and there is no risk of physical loss or damage, no need to duplicate plaster models to set-up the model in order to make a treatment plan.

Measurements with CBCT on the sum of mesiodistal and inter premolar width had very strong accuracy with the control ($R > 0.90$). Mesiodistal width measurement of teeth on CBCT is done by measuring the anatomic contact between one tooth with another tooth from the occlusal view. This study uses the CBCT measurement method with a segmentation system in order to obtain accurate measurement results. CBCT segmentation method provides high accuracy regarding mesiodistal tooth size, inter canine width, intermolar width, and arch length compared to 2D digital scan method, while non-segmented CBCT method provides good accuracy only for inter canine width, intermolar width. The CBCT segmentation method has clear visibility of the outline of each tooth so that the measurement of the mesiodistal width of the teeth in this study obtained measurement results with very good accuracy. The use of CBCT is still not very often used because of its high cost and additional training required, but CBCT has several recognized indications in orthodontics such as assessment of impaction and ectopic teeth, assessment of pharyngeal airway, assessment of mini implant placement, evaluation of craniofacial abnormalities, evaluation of resorption. root, and planning and evaluation of orthognathic surgery.

Figure 1. A. Measurement of typodont, B. 2D digital scan, C. Measurement of IOS 3D, D. Measurement of CBCT segmented methods

Figure 2. Distribution graph of the regression between methods on the measurement of mesiodistal width.
Conclusion
Overall, the conclusion of the study is that conventional measurement methods, 2D digital scan, 3D intraoral scanning, and CBCT are accurate in measuring the sum of mesiodistal width and inter premolar width.

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Conflict of Interest
The authors report no conflict of interest.

References

Figure 3. Distribution graph of the regression between methods on the measurement of inter premolar width.

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