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Evaluation of Diagnostic Accuracy, Measurement Sensitivity, Inter-rater Reliability between Manual and Digital Measurements of Pre-Treatment Plaster Study Models of Orthodontic Patients.

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ABSTRACT

Introduction: Orthodontic diagnosis is the key factor in establishing the goals of successful treatment. Digital technology has vastly integrated, with the ultimate aim of a “paperless” orthodontic office. At present, virtual computerized models are available for performing all required measurements.**Objective:**(i) The purpose of this study was to evaluate diagnostic accuracy and measurement sensitivity of manual and digital measurements of pre-treatment plaster models of orthodontic patients. (ii) Inter-rater reliability between manual and digital measurements of pre-treatment plaster study models of orthodontic patient.**Materials and method:** 30 study models with permanent dentition were selected and scanned using 3Shape scanner. Manual measurements were made using four different methods 1) Vernier calliper (manual), 2) Digital vernier calliper, 3) divider and 4) Digital scanning. Digital scanning was made using EXOCAD dental software. 11 variables included were maxillary and mandibular inter-canine width, inter-premolar, inter-molar width,overjet,overbite,maxillary and mandibular arch perimeter and palatal height.Statistical analysis was done by using SPSS software version 16.0.**Result:**In mean and standard deviation between the four methods of measurement in maxillary and mandibular variables, onlyoverjet(7.3 $\pm$ 3.9)in digital scanning and arch perimeter (86.8 $\pm$ 9.8 and 55.8 $\pm$ 5.0) in digital vernier calliper by observer 1 differed much from other methods of measurement. **Conclusion:**The digital model and manual model measurements had measurement sensitivityin most of the variables. The manual methods of measurement in pre-treatment models had more accuracy than the digital models.There was good correlation between the observers in most of the measurements.

INTRODUCTION

In orthodontics, diagnostic aids are an integral part of treatment planning, of which research models are one of the most relevant. Manual and virtual models of analysis can be three-dimensional.[1]

The "gold standard" method for model analysis was manual vernier calliper measurement of Plaster models.[2-5] Manual models are made of type IV plaster, but they have disadvantages such as breakage, problems with storage, potassium sulphate release.[6]With digital models, these disadvantages can be solved.[7]Align Technology Inc. (San Jose, California, USA) launched orthocad, a digital model service based on a patented plaster model scanning process, in 1999.Three years later, via laser scanning, GeoDigm cop (Falcon heights, Minnesota USA) introduced 'e-models'.[8]1) Laser scanning of impressions or plaster models 2) CBCT of orthodontic impressions or plaster models 3) Direct, intra-oral dental arch scanning or in-office plaster model scanningare methods of creating interactive orthodontic research models.[9]With divider and scale, digital and manual vernier callipers, measurements on the manual models can be carried out. Software such as orthocad, dolphin, onyxceph3,[10]radiocef 2000,[11] cecile3, version 2.554.2 beta[12] with STL files can be used to calibrate digital models.

By comparing manual measurements obtained from traditional plaster casts with a digitalized model of the cast taken by a photocopier, Schirmer and Wiltshire performed space analysisand their research suggested that the plaster model was the most accurate and reliable measurement source.Kumar et al[13] concluded that, by comparing tooth width measurements and measured anterior and overall Bolton ratios on digital models (CBCT, CAD/CAM) with those of plaster models, digital models of CAD/CAM and CBCT did not vary significantly from those of plaster models.Although the authors of the studies[14,15]concluded that no statistically significant difference

between manual and digital methods was observed between precision and sensitivity of measurement.

digital plaster sample models, such as 1) Vernier calliper (manual) 2) Digital vernier calliper 3) Divider 4) Digital

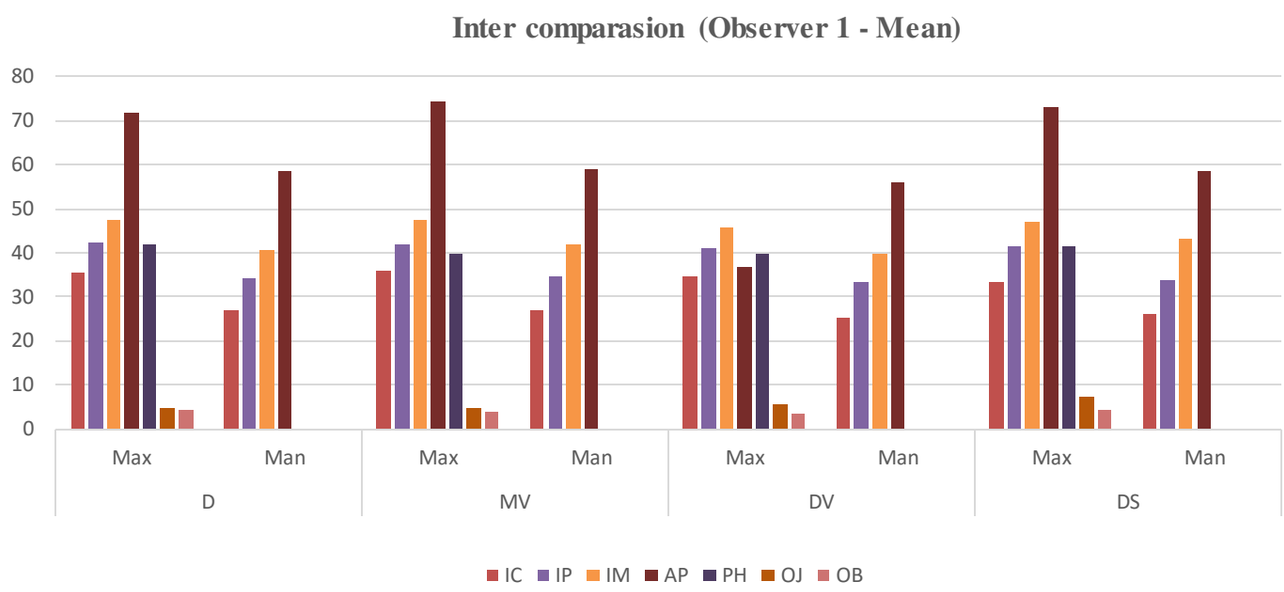

Fig. 1 **Inter-comparison of four methods (observer 1)**[**D**- Divider,**MV**-Manual Vernier Calliper, **DV**-Digital Vernier Calliper, **DS**-Digital Scanning, **IC**- Inter Canine Width, **IP**-Inter Premolar Width, **IM**- Inter-Molar Width, **AP**-Arch Perimeter, **PH**- Palatal Height, **OJ**-Overjet, **OB**-Over Bite, **Max**- Maxilla, **Man**- Mandible]

Rossini et al[16]systematic review notes that major variations were correlated with mandibular 1st and 2nd inter-molar width, disparities in tooth size, arch perimeter, Bolton analysis, torque, tip, and rotation. All of these changes are caused by 1) poor proximal surface accuracy, which makes it more difficult to position landmarks. 2) Improved virtual setup precision between digital and plaster models. 3) The shapes of virtual models may be changed by the superimposition of moving objects.There are no studies comparing the four measurement gauges between manual and

measurements in model analysis.The aim of the research is to assess diagnostic accuracy, sensitivity to measurement, inter-rater reliability between pre-treatment plaster study models of orthodontic patients' manual and digital measurements.

Materials and Methods:

The method of sample selection is non-probabilistic. This cross-sectional study includes study models of 30 subjects (sample sizecalculated with G*power version 3.1.9.2- Tagore DentalCollege and Hospital, Chennai.) with permanent dentition who will commonlyundergo an orthodontic treatment at

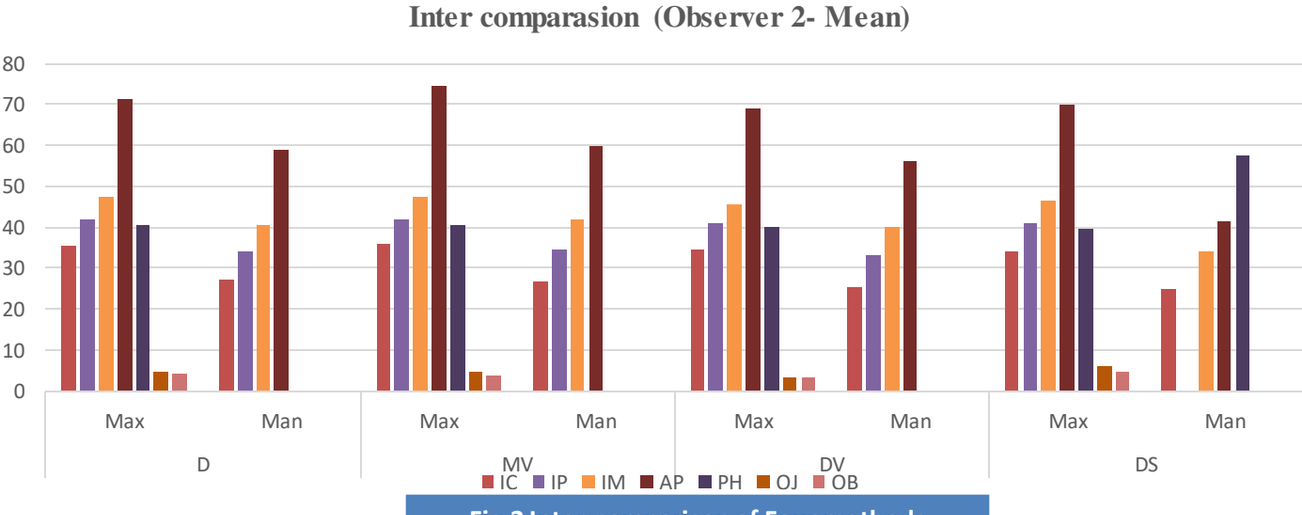

Fig.2 Inter-comparison of Four methods

Department of Orthodontics, Tagore Dental College & Hospital, Rathinamangalam, and Chennai were considered.The inclusion criteria for the plaster models were as follows: patients older than 13 years old; both sexes; permanent dentition; no loss of apparent dental substance resulting from attrition or decay; and no missing teeth from the first molar to the first molar. The exclusion criteria are as follows: plaster models from patients who previously received orthodontic or dentofacial orthopedic treatment; with previous surgical treatment; with changes in craniofacial growth; and with dental alterations of the size and number of the teeth.

Table.1 Intra-comparison of four methods - observer 1

Variables		D		M.V		D.V		D.S	
		MAX	MAN	MAX	MAN	MAX	MAN	MAX	MAN
IC	D	0	0	0	0	0	0	0	0
	MV	0	0	0	0	0	0	0	0
	DV	0	0	0	0	0	0	0	0
	DS	0	0	0	0	0	0	0	0
IP	D	0	0	0	0	0	0	0	0.19*
	MV	0	0	0	0	0	0	0	0
	DV	0	0	0	0	0	0	0	0
	DS	0	0	0	0	0	0	0	0
IM	D	0	0	0	0	0	0	0	0.107*
	MV	0	0	0	0	0	0	0	0.166*
	DV	0	0	0	0	0	0	0	0.065*
	DS	0	0	0	0	0	0	0	
AP	D	0	0	0	0	0.68*	0.02	0.04	0.17*
	MV	0	0	0	0	0.46*	0	0.04	0.05
	DV	0	0	0	0	0	0	0.48*	0.26*
	DS	0	0	0	0	0	0	0	
PH	D	0		0		0		0	
OB	MV	0		0		0		0	
OJ	DV	0		0		0		0	
	DS	0		0		0		0	

For digital measurement, 3shapes scanner was used and for manual measurement, Digital vernier calliper(Safeseed ® Electronic Digital Vernier Calliper Ruler Carbon Fiber Composite 6inch 150mm, DIGICALPLBK with accuracy of +/- 0.1mm/0.01'', Chennai), Manual vernier calliper(SSU 268- Silver Vernier Calliper Range, 15 X 15 X 15 Cm, Tamil Nadu), and Divider (utc mathematical instruments T.M. no 324345, Delhi) are were used. Measurements on the models using both methods were as follows: maxillary and mandibularintercanine width (from cusp tips of the right and left canines) ; maxillary and mandibularinterpremolar (buccal cusp tip from right and left premolar), maxillary intermolar width(distance between the left permanent molar to the same of the right at its central pit on the occlusal surface); overjet (horizontal overlap of maxillary central incisor over the mandibular central incisor) ; overbite (vertical overlap of maxillary central incisor over the mandibular central incisor); maxillary arch perimeter; mandibular arch perimeter; and palate height. Measurements on the model were done according with ABO grading system for scoring dental casts and panoramic radiographs contains eight criteria: alignment, marginal ridges, buccolingual inclination, occlusal relationships, occlusal contacts, overjet, inter-proximal contacts, root angulation. For digital measurement, the models were scanned with Medit i500 version 2.0 scanner (Kelkar dynamics LLP, Nasik) and converted into STL file format which would assess by using Exo-cad software (Digitized and measured with Exocad dental CAD (8.1/8/7 inc.600W, USA).

Statistical Analysis:

The data obtained was entered in Microsoft excel 2010 and analysed with SPSS (version 16.0). Descriptive statistics was given by mean and standard deviation.The parameters measured by two investigators are assessed for inter-rater agreement using Pearson's correlation, where 0-0.3 is low agreement,0.3-0.6 is moderate agreement,0.6-1 is good agreement.The agreement between various methods of measurements was assessed individually by Pearson's correlation and reported.Same scale of agreement was followed. The correlation agreement was accepted only when the probability was less than 0.05. It was found to be not statistically significant (P>0.05).

RESULT

Mean and standard deviation between four methods of measurement in maxillary and mandibular variables in observer 1 (Fig.1,2) shows that overjet(7.3 ± 3.9)in digital scanning and arch perimeter (86.8 ± 9.8 and 55.8 ± 5.0) in digital vernier caliper differed much from other methods of measurement.

The intra comparison of variables between Divider, Manual Vernier calliper, Digital Vernier Calliper and Digital Scanning methods in observer 1 were done using Pearson correlation

(Table.1) shows that some results differed significantly (P < 0.005).

Table 2- Inter-rater Agreement by Pearson Correlation

INTERRATER AGREEMENT BY PEARSONS CORRELATION								
	D		M.V		D.V		D.S	
	MAX	MAN	MAX	MAN	MAX	MAN	MAX	MAN
IC	0.9978	0.9672	0.9733	0.9431	0.9512	0.9012	0.8282	0.7996
P- Value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
IP	0.9961	0.9441	0.9961	0.8736	0.9690	0.8799	0.6172	0.6440
P- Value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
IM	0.9949	0.9941	0.9965	0.9278	0.9603	0.8825	0.7983	0.1472
P- Value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.44*
PH	0.6189		0.9999		0.9831		0.4989	
P- Value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AP	0.9996	0.9566	0.9955	0.7620	-0.1505	0.7143	0.3834	0.2706
P- Value	0.00	0.00	0.00	0.00	0.43*	0.00	0.052*	0.163*
OB	0.9374		0.8327		0.8515		0.4568	
P- Value	0.00		0.00		0.00		0.00	
OJ	0.9020		0.8919		0.3850		0.5365	
P- Value	0.00		0.00		0.051*		0.00	

On Comparison of mandibular inter-premolar distance between digital scanning and divider were found to be non-significant. Between digital vernier calliper and divider, the maxillary arch perimeterwas non- significant and also same indigital vernier with manual vernier calliper. The maxillary and mandibular arch perimeter showed non- significant between digital scanning and divider. Digital scanning and digital verniercalliper comparisonshowed non- significant in mandibular arch perimeter.

The parameters measured by two investigators were assessed for inter-rater agreement using Pearson correlation are given in Table.2, where 0-0.3 is low agreement, 0.3 -0.6 is moderate agreement, 0.6-1 is good agreement. Same scale of agreement was followed. The correlation agreement was accepted only when the probability was less than 0.005. It was found to be not statistically significant (p >0.05) in mandibular inter-molar distance, maxillary and mandibular arch perimeter in digital scanning, maxillary arch perimeter, overjet in digital vernier calliper measurement.

DISCUSSION

The trend to virtual models in orthodontics is clear and different software programmes are available to perform virtual model analyses.[17]Several studies have compared different model analysis software programmes and conventional manual analysis.[6,18-20] In the present study, Exocad soft were used to digitise the variables, where digital models were scanned by 3 shapes extra-oral scanner compared for first time with the manual analyses with manual, digital vernier calliper and divider and scale. 30 samples were calculated as an adequate number which has agreement with,[4,12,15,20]where they selected 10 and 25 models.

Several methods of obtaining data for a full dental arch are direct intra- oral scanning, extra-oral scanning of impression and models.[19-22]In our study, we scanned the plaster models using Medit extra- oral scanner to enhance conversion of already existing plaster models into digital models. Measurements made by manual calliper are regarded as the gold standard against which other techniques are compared for accuracy.[3-5,21] On comparison of four methods of measurement, divider has significant difference with manual calliper measurement.[4-5]Mean and Standard deviation of digital vernier calliper and digital scanning were lesser than manual which has similar result with study by Santoro et al.[3]

The inter-canine did not display major variations in four measurement methods because the place canine tip is much more relaxed in accordance with Verma et al.Non- statically difference found in arch perimeter, inter-premolar, inter- molar distance due to difficulty in locating the landmarks in digital scanned models making due to malocclusion in the pre-treatment models making the measurement difficult where measurement of the arch length and arch width on digital and manual models are reliable. In digital vernier calliper measurement non- statically difference found in overjet arch perimeter, inter-premolar, inter-molar distance due to absences of sharp and pointed less pointer in digital vernier calliper.

Because of magnification error, difference in variance in the horizontal plane used and also 3-dimensional image shown on 2-

dimensionalscreen, the overjet measurement showed difference between manual and digital model.[22]The relationship between the two observersshowed a strong association.

CONCLUSION

This study concludes that

1. Divider measurement does not show much difference in comparing with caliper measurement.
2. The digital models and manual models' measurement have measurement sensitivity in most of the variables.
3. The manual methods of measurement in pre-treatment models have more accuracy than digital models.
4. There was a good correlation between the observer in most of the measurements.

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