ISSN: 1110.435X

Egyptian
Orthodontic Journal

RELIABILITY OF MEASUREMENTS BETWEEN CONVENTIONAL CASTS, LASER SCANNED CASTS AND INTRAORAL SCANNING

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Keywords: Digital model, Intraoral scanning, cast scanning, intra-arch tooth measurements.

Abstract:

The aim of this study was to compare tooth measurements obtained by two differently acquired digital model and conventional plaster cast measurements. **Materials and methods:** This study comprised 40 patients. Digital casts were obtained by two methods: Intraoral scanning by carestream intraoral scanner CS3600 powder free and model scanning by cast scanner Sirona InEos X5 scanner. Three study groups were obtained; Group 1: conventional dental casts, group 2: digital casts obtained with powder free intraoral scanning and group 3: digital casts obtained by cast scanner. Inter-canine and intermolar widths in addition to individual tooth measurements were made using Viewbox program for digital casts and digital caliper for the plaster cast. **Results:** No statistically significant difference between three groups regarding all measurements had been found. **Conclusion:** This study confirms that intraoral and model scanning are accurate and reliable as plaster casts poured into alginate impressions.

Literature Review

The breakthrough of technology has its impact on many things in our lives; including orthodontics. Orthodontists can study their cases better thanks to the introduction of three dimensional digital study models, and their softwares. (1)

Panoramic and cephalometric x-rays and patient photographs when combined with digital models, enable the clinician to set a precise problem list and treatment plan(2-4)

Digital models although not so popular among orthodontists(5), are much better than traditional plaster casts as they, offer an easy and fast way to share information with others, save space of the plaster and casts storage area, don't require timely, messy, and costly laboratory procedure, and are not subjected to breakage and deterioration over time.(3)

Some of the merits of digital models over plaster casts include:

- **Easy and quick accessibility of all patient needed information digitally.**
- **Diagnostic setup for different proposed treatment plans is easily made.**

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- **Easy transfer of the digital patient data for further consultation, patient education and insurance issues.**
- **Easier occlusion analysis and scoring for example using the (ABO) scoring system.**

Any advantages attributed to digital models would be of no value if they were not as reliable and accurate as poured models, regarding measurements taking.

According to ISO 5725-1, Accuracy (precision and trueness) is a very important criterion when comparing scanned to poured models. Trueness is how close is the scanned arch to its true form. while precision has the same meaning as reproducibility, i.e. how accurate could the model be reproduced by multiple scans.

More precision means that different measurements are very close to each other. [6] while trueness mean that the scanned arch is close to the true arch. [7]

Wiranto et al [8] and Naidu and Freer [9] to assess accuracy of intraoral scanners and their results suggested a high degree of accuracy. A systematic review also found digital models to be very valid. [10]

Needless to say new methods and equipment should be well studied in order to substitute older ones, and since few studies have compared digital to traditional models, our study was designed with the null hypothesis that measurement accuracy on poured models is similar to measurements on digital models.

Materials and Methods

To be enrolled in this study the subject had to have full permanent dentition excluding second and third molars, no impacted or supernumerary teeth.

Any subjects with mental disabilities or craniofacial syndromes were excluded from the study.

Following sample size estimation, this study comprised 40 patients. Patients ranged in age from 12 to 16 years and consisted of 24 boys and 16 girls in permanent stage of dentition.

Mean chronological age of the enrolled sample was 14.2 years.

Alginate impressions were taken (Orthoprint, Zhermack). The impression was taken according to the manufacturer accepted guidelines. [12]

Alginate impressions were immediately poured with type IV gypsum to avoid dimensional change, then trimmed according to a wax bite taken in centric occlusion.

Intraoral scanning was performed by the same clinicial at the same visit.

The digital casts were prepared by two methods.

First method: Intraoral scanning by carestream intraoral scanner CS3600 powder free. (Figure 1)

Second method: Maxillary stone cast was scanned by cast scanner Sirona InEos X5 scanner and digital cast was obtained. (Figure 2)

Three study groups were obtained

Group 1: conventional dental casts

Group 2: digital casts obtained with powder free intraoral scanning

Group 3: digital casts obtained by cast scanner

Figure 1: Intraoral scanner used in the study

Figure 2: Cast scanner used in the study

The following measurements were made:

- **Maxillary inter-canine width, from cusp tip to cusp tip.**
- **Maxillary inter-molar width, from the mesiobuccal tip of both first molars.**
- **Individual tooth size was measured as the distance between the anatomic contact points; from the central incisor to the first molar.**

Landmarks were identified on each stone cast by one examiner and repeated for accuracy by a second examiner, at two separate times at least 2 weeks apart. When measurements differed by more than 0.025 mm, the parameters were re-measured until the reading fell within the allowable error.

Intra-examiner reliability was assessed by repeated positions of the landmark and digitization of the same points on the stone and digital casts.

On the stone casts, measurements of the tooth mesiodistal diameters were performed directly with a digital caliper (absolute Digimatic caliper, Mitutoyo, Japan).(Figure 3)

On the digital casts, Viewbox 4.0 was used; both groups of measurements were made by digital ruler provided by the program.(Figure 4)

Figure 3: Digital caliper used in the study

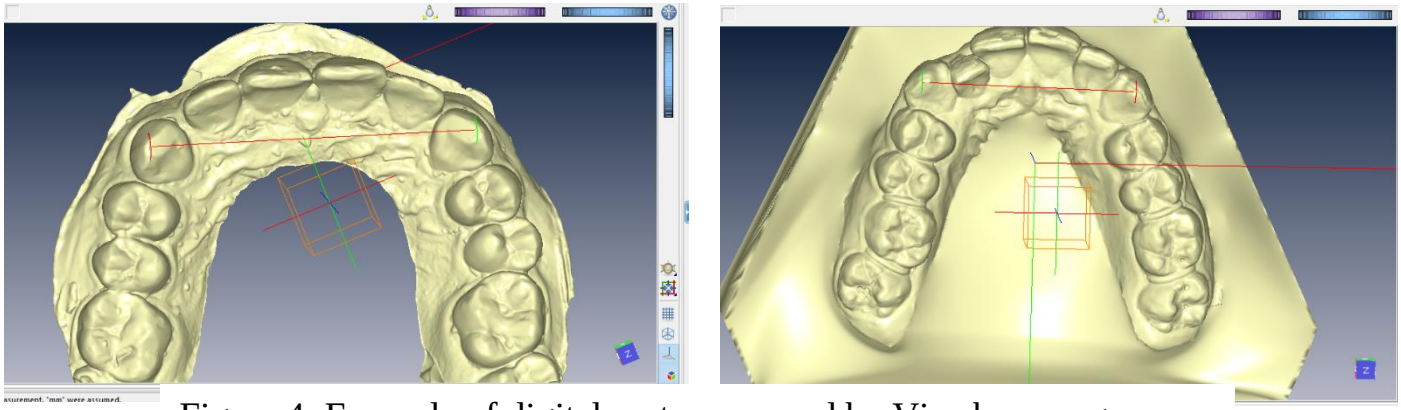
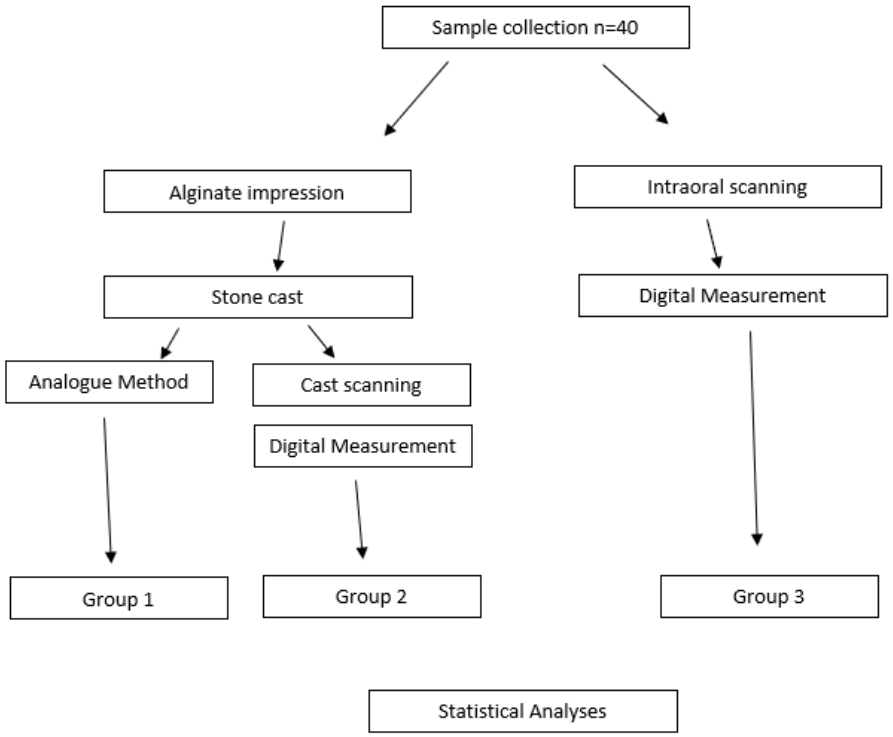


Figure 4: Example of digital casts measured by Viewbox program

Flow chart showing the sequential steps of the study



Results

Sample size estimation was made. To evaluate the measurement error, both analogue and digital measurements are repeated after a period of two weeks by the same operator.

Data were fed to the computer using IBM SPSS software package version 24.0. Quantitative data were described using mean and standard deviation for normally distributed data.

For normally distributed data, comparison between more than two population were analyzed F-test (ANOVA) to be used, followed by post hoc test to compare between each two groups.

Significance test results are quoted as two-tailed probabilities. Significance of the obtained results was judged at the 5% level.

Table (1): Comparison between the three studied groups regarding the central and lateral measurements in different studied groups.

	Manual method	Intraoral scanning	Cast scanning	ANOVA P value	P1	P2	P3
Right central							
Range	7.13-10.33	7.52-10.4	7.64-10.38	1.21	0.454	0.370	0.412
Mean±S.D.	8.736±0.899	8.784±0.869	8.877±0.867	0.365			
Left central							
Range	7.77-10.5	7.29-10.66	7.43-10.76	1.28	0.367	0.447	0.332
Mean±S.D	8.912±0.819	8.766±0.971	8.970±0.994	0.321			
Right lateral							
Range	6.3-8.9	6.18-9.09	6.15-8.94	0.905	0.455	0.426	0.384
Mean±S.D	6.947±0.995	7.002±1.037	6.857±1.025	0.425			
Left lateral							
Range	6.25-8.68	6.15-8.45	6.14-8.67	0.889	0.410	0.414	0.498
Mean±S.D	7.002±0.951	6.901±0.895	6.903±0.942	0.611			

P1 comparison between manual method and intraoral scanning

P2 comparison between manual method and cast scanning

P3 comparison between intraoral scanning and cast scanning

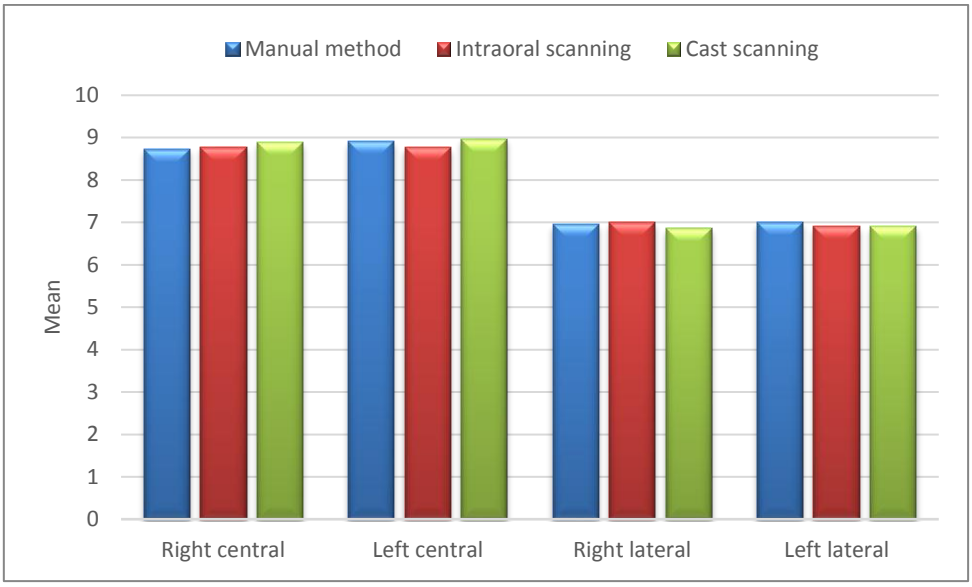


Figure 5: Comparison between the three studied groups regarding the central and lateral measurements in different studied groups.

Table (2): Comparison between the three studied groups regarding the canine and 4th measurements in different studied groups.

	Manual method	**Intraoral scanning**	**Cast scanning**	**ANOVA P value**	**P1**	**P2**	**P3**
Right canine							
Range	6.55-9.2	6.78-9.12	6.52-8.87	0.785	0.481	0.443	0.425
Mean±S.D	8.004±0.946	8.026±0.918	7.939±0.956	0.562			
Left canine							
Range	7.15-8.69	7-8.95	6.83-8.88	0.905	0.423	0.461	0.395
Mean±S.D	7.876±0.631	7.939±0.725	7.842±0.785	0.411			
Right 4							
Range	5.84-7.86	5.66-7.58	6.1-7.75	1.01	0.239	0.380	0.321
Mean±S.D	6.972±0.599	6.768±0.596	6.891±0.507	0.398			
Left 4							
Range	5.95-7.78	5.66-7.92	5.85-8.04	0.789	0.456	0.466	0.492
Mean±S.D	6.798±0.607	6.831±0.664	6.824±0.678	0.469			

P1 comparison between manual method and intraoral scanning

P2 comparison between manual method and cast scanning

P3 comparison between intraoral scanning and cast scanning

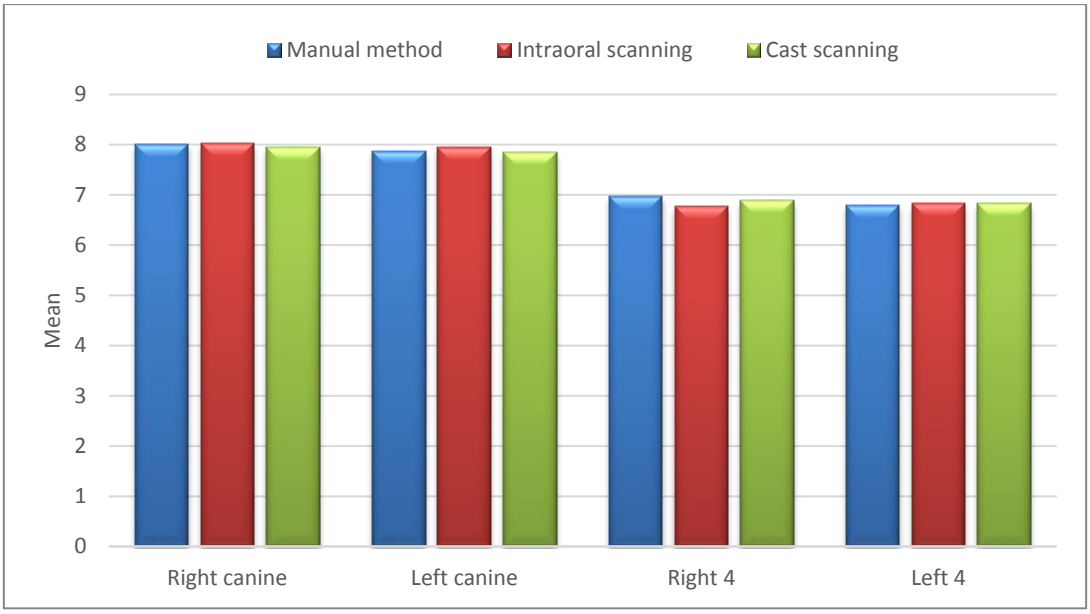


Figure 6: Comparison between the three studied groups regarding the canine and 4th measurements in different studied groups.

Table (3): Comparison between the three studied groups regarding the 5th and 6th measurements in different studied groups.

	Manual method	**Intraoral scanning**	**Cast scanning**	**ANOVA P value**	**P1**	**P2**	**P3**
Right 5							
Range	5.67-7.35	5.36-7.22	5.88-7.2	1.085	0.385	0.429	0.444
Mean±S.D	6.551±0.602	6.468±0.588	6.504±0.489	0.365			
Left 5							
Range	5.88-7.1	5.57-6.93	5.22-7	0.985	0.325	0.263	0.428
Mean±S.D	6.510±0.448	6.407±0.499	6.362±0.518	0.458			
Right 6							
Range	8.32-11.56	8.05-11.19	8.4-11.39	1.41	0.265	0.459	0.300
Mean±S.D	10.333±0.944	10.043±0.975	10.287±0.951	0.207			
Left 6							
Range	8.98-11.74	8.6-11.36	8.72-11.82	0.982			
Mean±S.D	10.384±0.823	10.234±0.808	10.329±0.918	0.441	0.351	0.447	0.410

P1 comparison between manual method and intraoral scanning

P2 comparison between manual method and cast scanning

P3 comparison between intraoral scanning and cast scanning

Figure 7: Comparison between the three studied groups regarding the 5th and 6th measurements in different studied groups.

Table (4): Comparison between the three studied groups regarding inter-canine and inter-molar width measurements in different studied groups.

	Manual method	**Intraoral scanning**	**Cast scanning**	**ANOVA P value**	**P1**	**P2**	**P3**
Inter-canine width				1.58	0.485	0.473	0.487
Range	30.28-45.44	30.44-45.2	30.19-45.05	0.142			
Mean±S.D	35.619±4.586	35.538±4.487	35.469±4.600				
Inter-molar width					0.455	0.402	0.447
Range	46.45-59.38	46.37-59.08	46.25-59.24	1.07			
Mean±S.D	51.720±4.079	51.498±4.087	51.236±4.078	0.325			

P1 comparison between manual method and intraoral scanning

P2 comparison between manual method and cast scanning

P3 comparison between intraoral scanning and cast scanning

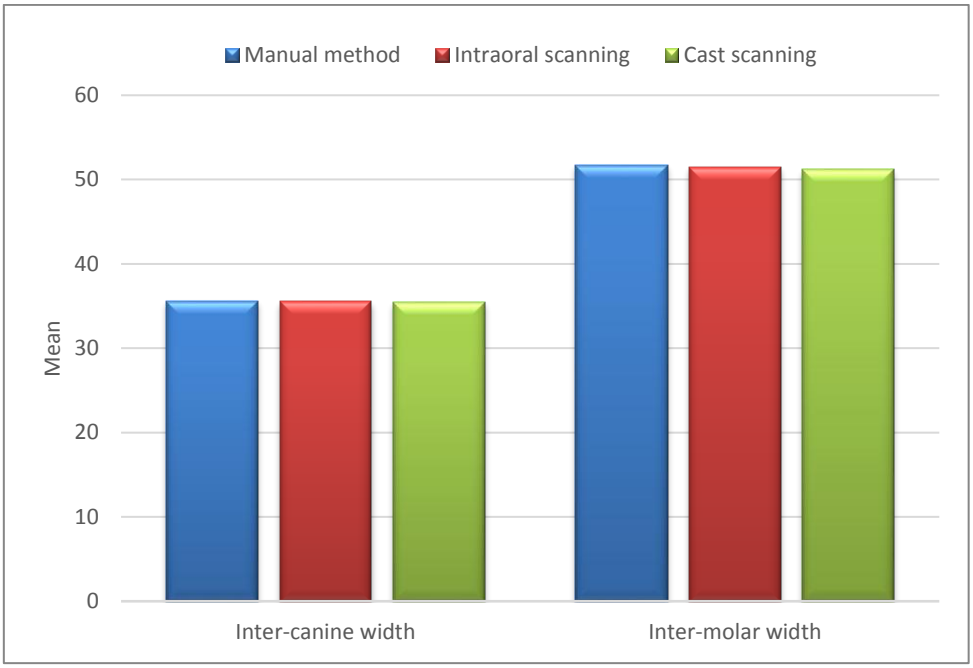


Figure 8: Comparison between the three studied groups regarding inter-canine and inter-molar width measurements in different studied groups.

Discussion

The null hypothesis was accepted. Digital casts have comparable accuracy and measurement reproducibility compared to conventional casts. Plaster casts, digital casts obtained by intraoral scanning, and scanned casts showed no significant differences in the measurements accuracy.

The precision of intraoral digital scans has been evaluated in several studies reporting its high accuracy. [13]

Many studies evaluated single tooth measurement, thus reporting the accuracy of the scanned digital casts when evaluated from restorative dentistry goals point of view. [14,15]

Other studies that used intraoral scanners for full mouth scanning, concluded that they are acceptable for diagnosis and treatment planning. [16, 17]

Other studies reported slight errors in the position of teeth ranging from −0.05 to 0.21mm and errors for arch length and width from −0.07 to 0.17 mm. [18]

Conclusions

The results of this study confirm the potential of using intraoral scanners to obtain data as precise as alginate impressions as well as scanned digital casts for orthodontic applications. Intraoral scanners as regards to its small size and ease of use, are capable of making digital models useful in diagnosis, treatment planning, formulation, and documentation of treatment progress.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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