Comparing Methods for Dental Casts Measurement

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ABSTRACT— ***Traditionally, conventional dividers and sliding calipers, analog or digital, have been used to measure dental casts manually. Today, several digital methods are available for measuring tooth size. The digital methods of measurements were gathered by transforming the 3D dental plaster casts into 2D form. Scanners, Photocopy machine, Digital camera are means to make this transformation. OBJECTIVE: This research was to find out which method of dental casts measurement is the best accuracy and reliability. METHOD: Mandibular dental casts of 10 patients, mixed gender, taken after finishing orthodontic treatment were formed by using 3 different dental stones color. The variables (tooth size, intercanine width, intercanine depth, intermolar width, intermolar depth) were measured using 7 methods. All data were analyzed statistically. Anova, followed by independent t-test, were applied to test the difference of variables measured in sexes, colors and methods. Alpha Cronbach was used to test the reliability among methods. To compare the accuracy among methods, we applied sensitivity, specificity and ROC test of variables among methods. Regression analysis was applied for several variables that showed significantly different (p<0.05) as a result of different measurement methods compared to gold standard. RESULT: Colors did not play important role for the result of measurement gathered from different methods. Sexes should be considered taking part for different value of measurement. CONCLUSION: 3D measurement still gave the best measurement result, despite the difficulties in handling the dental casts. With some mathematical equations derived from regression analyses, 2D measurement could give almost the same result as 3D measurement.***

Keywords— Dental casts, Measurement methods, 2D

1. INTRODUCTION

The success of orthodontic treatment was based on a comprehensive diagnosis and treatment plan. One of the information in developing diagnosis was collected from casts analysis. Study casts have always been important in orthodontics. They are tools of basic diagnosis that can tell us about the patients' occlusion in 3 planes of spaces. We could gain tooth size, space analysis, dental arch form and the accordance of tooth size-arch form, etc.

Traditionally, conventional dividers and sliding calipers, analog or digital, have been used to measure dental casts manually. Today, several digital methods are available for measuring tooth size. The digital methods of measurements were gathered by transforming the 3D dental plaster casts into 2D form. Scanners, Photocopy machine, Digital camera are means to make this transformation. Like other digital methods, there are some advantages of using digital measurements over manual measurement methods such as speeding up the measurement process, eliminating the need to store stone models and facilitating to diagnostic records.

Hunter stated that on average the use of dividers gave a significant larger measurement of tooth size than did sliding calipers. [1] It is clearly more difficult to measure teeth in the mouth than on the plaster casts. Stellhart mentioned that Bolton analysis measured on crowding cases using that method showed discrepancy on measurement more than 1.5mm.[2]

Sondhi did a research on casts measurement using telelens camera on a certain distance to get the projection of dental casts put on the surveyor. He digitized the picture and according to him this method was reliable.[3]

After marking some landmarks on dental casts with a black 0.3-mm-thick pencil, Taner scanned the casts, digitized using a new computer program, and made the measurement. He found out that the error from this method was less than 0.5mm.[4]

Noroozi photocopied the occlusal surface of dental casts with a 100-mm ruler in the field to allow for

calculation of enlargement. The photocopies were scanned on a flatbed transparency scanner and a digital image of the occlusal surface of each casts was prepared. These digital images were transferred to AutoCAD environment, and digitized on a certain landmarks. According to him. An average enlargement from this transformation was not statistically significant.[5] To calculate the arch perimeter, he used a computer program written in Microsoft Visual Basic.

Braun oriented dental casts in a Brown and Sharp Micro Val coordinate measuring machine, used extensively in the precision machine tool industry, to record the corresponding each measurement point to a computer data file. He analyzed the dental arch shape using beta function.[6]

Zilberman evaluated the validity of tooth size and arch width measurements using conventional and Three-dimensional virtual orthodontic models. He found out that measurement using digital calipers on dental plaster casts was a suitable instrument for scientific work. However using measurement of 3D virtual models examined by OrthoCAD was clinically acceptable.[7]

Dental plaster casts were formed by pouring the stone into oral impression taken on dental chair. It showed the actual patients' oral condition. Kinds and color of dental plaster casts are varied. White orthodontic stones, dental stones (blue), and hard stone (red) could be used. Different color was suspected influencing the transformation from 3D to 2D form.

With the needs of accuracy and reliability of dental casts measurement, therefore, the objective of this research was to find out which method is the best, whether gender plays role in the variables of measurement and whether color influence the transformation of dental casts.

2. METHODS

Mandibular dental casts of 10 patients, mixed gender, taken after finishing orthodontic treatment were evaluated. The casts of each patient were formed by using 3 different colors of dental stones. White represented white orthodontic stone. Blue represented dental stone. And red represented hard dental stone. The criteria of each cast were a good and complete dental cast without any broken part, the complete number of the teeth up until second molars, and without any polishing agent. The parameters of each casts defined as follows (Fig.1):

1. Tooth size: distance between contact points of each tooth measured perpendicular the occlusal surface for 3D methods and on the occlusal surface for the 2D methods. The accuracy was 0.01mm
2. Intercanine Width (CW): distance between the distal contact points of the canines measured perpendicular the occlusal surface for 3D methods and on the occlusal surface for the 2D methods. The accuracy was 0.01mm.
3. Intermolar Width (MW): distance between the distal contact points of the first molars measured perpendicular the occlusal surface for 3D methods and on the occlusal surface for the 2D methods. The accuracy was 0.01mm.
4. Canine Depth (CD): distance between the contact point of the incisors and a line connecting the distal contact points of the canines measured perpendicular the occlusal surface for 3D methods and on the occlusal surface for the 2D methods. The accuracy was 0.01mm.

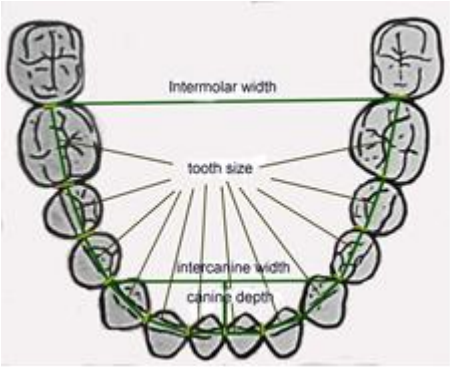

Figure 1: Variables of Measurement

Each variable from all the dental casts was measured using 7 methods defined as follows:

I. Measuring using Vernier Sliding Calipers 0-150mm with the accuracy of 0.05mm (Fig 2A)

II. Measuring using Digital Sliding Calipers 0-150mm with the accuracy of 0.01mm (Fig 2B)

III. Transforming the casts using Photocopy machine (Xerox), measuring the photocopies using Digital Sliding Calipers 0-150mm with the accuracy of 0.01mm.

IV. Transforming the casts using Scanner (Canon LIDE20), measuring the scans using Digital Sliding Calipers 0-150mm with the accuracy of 0.01mm.

V. Transforming the casts using Scanner (Canon LIDE20), measuring the scans using Image Tool for Windows version 2.00 (A public domain program downloaded from http://ddsdx.uthsca.edu/) with the accuracy of 0.01mm

VI. Transforming the casts using Digital Camera (Casio QV-2800UX) without flash, measuring the scans using Image Tool for Windows version 2.00 (A public domain program downloaded from http://ddsdx.uthsca.edu/) with the accuracy of 0.01mm

VII. Transforming the casts using Digital Camera (Casio QV-2800UX) with flash, measuring the scans using Image Tool for Windows version 2.00 (A public domain program downloaded from http://ddsdx.uthsca.edu/) with the accuracy of 0.01mm.

2A **2B**

Figure 2A. Vernier Sliding Calipers 0-150mm, 2B. Digital Sliding Calipers 0-150mm

To calibrate the enlargement that might be occurred during transformation 2D dental casts, Paredes suggested sit the dental casts surrounded by a sheet of millimeter graph paper during this transformation.[8]

3rd Method **4th and 5th Method** **6th Method** **7th Method**

Figure 3: The 2D Transformation Result

3. RESULT AND DISCUSSION

The mandibular dental casts from 10 patients (3 men and 7 women) were duplicated into 3 different dental stone colors (white, blue and red). Tooth size (3.6-4.6), Intercanine width (CW), Canine Depth (CD), and Intermolar Width (MW) were measured using 7 different methods. So, there were 210 samples for each variable. The distribution of data gathered from all methods can be seen in tabel 1. All variables showed normal distribution.

Tabel 1.The Distribution of the Data

Variable	∑	Mean	Std. Dev.	Min	Max
3.6	210	11.90657	0.791292	10.48	15.52
3.5	210	8.069048	0.599488	6.25	10.02
3.4	210	8.086762	0.639469	6.7	9.95
3.3	210	7.306905	0.540356	5.86	9.02
3.2	210	6.39819	0.531026	4.98	8
3.1	210	5.68481	0.473875	4.47	7.44
4.1	210	5.701952	0.468792	4.46	7
4.2	210	6.288381	0.526132	4.97	7.79
4.3	210	7.225	0.587001	6.04	9.3
4.4	210	8.032524	0.61105	5.58	9.81
4.5	210	7.993429	0.585364	7	9.8
4.6	210	11.75648	0.713259	10.35	14.06
CW	210	32.80481	2.539883	26.96	39.61
CD	210	10.65867	1.601877	7.01	14.92
MW	210	47.72324	4.043894	38.14	57.14

Homogeneity test and independent t-test for each variable compared to gender, did not show significant difference ($p>0.05$) except for 3.2, 3.1, 4.3, and DC. There was no statistical significant difference ($p>0.05$) for the homogeneity test and independent t-test of all variables compared to colors.

Anova for gender showed statistically significant difference ($p<0.05$) just for Intermolar width and Intercanine width. Reliability test (Alpha Crobach) for each method in measuring all the variables could be seen in table 2. The accuracy among methods could be seen in the sensitivity, specificity and ROC test of variables as figured in table 3.

Table 2: Reliability Test (Alpha Crobach) for each Method in Measuring all Variables

	METHODS						
Variable	alpha 1	alpha 2	alpha 3	alpha 4	alpha 5	alpha 6	alpha 7
3.1	0.8945	0.9099	0.8502	0.891	0.839	0.9509	0.946
3.2	0.8938	0.908	0.8473	0.886	0.8401	0.9475	0.9392
3.3	0.894	0.909	0.847	0.8803	0.8314	0.9454	0.9425
3.4	0.9042	0.9223	0.8523	0.8883	0.8565	0.9455	0.943
3.5	0.892	0.9081	0.8531	0.8862	0.8386	0.9471	0.9487
3.6	0.902	0.9177	0.8458	0.8953	0.8477	0.9486	0.9446
4.1	0.8965	0.91	0.846	0.8913	0.8465	0.9487	0.942
4.2	0.8878	0.9084	0.8546	0.8842	0.8394	0.9459	0.9466
4.3	0.8936	0.9127	0.8458	0.8889	0.8349	0.9456	0.9435
4.4	0.8942	0.9137	0.8725	0.8942	0.8543	0.9465	0.9434
4.5	0.9071	0.9176	0.8352	0.881	0.8299	0.944	0.9435
4.6	0.9007	0.9188	0.857	0.8966	0.8496	0.9469	0.9428
CW	0.8987	0.9169	0.8485	0.8853	0.8488	0.9439	0.943
CD	0.9006	0.9197	0.8511	0.8945	0.8406	0.9465	0.943
MW	0.9009	0.9188	0.8519	0.8969	0.8419	0.9488	0.945
Test scale	0.9037	0.9195	0.8594	0.8961	0.8518	0.9502	0.9474

Table 3: The Sensitivity, Specificity and ROC Test to all Variables among Methods

Variable	Sens	Spec	ROC	p
3.1	98.67%	0.00%	0.6003	0.02*
3.2	100.00%	0.00%	0.5614	0.168
3.3	92.00%	30.00%	0.5596	0.093
3.4	96.00%	50.00%	0.7549	0*
3.5	90.00%	26.67%	0.7626	0*
3.6	90.67%	26.67%	0.7578	0*
4.1	100.00%	0.00%	0.5689	0.052
4.2	100.00%	0.00%	0.4808	0.861
4.3	100.00%	0.00%	0.5161	0.393
4.4	98.00%	0.00%	0.6449	0.003*
4.5	90.00%	15.00%	0.7101	0*
4.6	96.00%	5.00%	0.6771	0*
CW	94.67%	10.00%	0.6532	0*
CD	99.33%	0.00%	0.615	0*
MW	95.33%	10.00%	0.6612	0.007*

* $p < 0.05$

Homogeneity test and independent t-test for each variable compared to methods of measurement showed varied different value for different method of measurement. With using 1st method as a gold standard, each method of measurement was compared using independent t-test (p=0.05). And the result of variables showed statistically difference (p<0.05) were as follows:

- 1st vs 2nd : IC
- 1st vs 3rd : 3.5
- 1st vs 4th : 3.6 and 3.5
- 1st vs 5th : 3.6, 3.5, 3.3, 4.2, 4.5, MW
- 1st vs 6th : 3.6, 3.5, 3.4, 3.1, 4.1, 4.3, 4.4, 4.5, 4.6, CW, CD, MW
- 1st vs 7th : 3.6, 3.5, 3.4, 3.1, 4.1, 4.3, 4.4, 4.5, 4.6, CW, CD, MW

Homogeneity test for all variables compared to gender showed no statistical significant difference (p>0.05) except for 3.2, 3.1, 4.3, and DC. This might be due to unequal distribution of sexes from the samples (3 to 7). There was no statistical significant difference (p>0.05) for the homogeneity of all variables compared to colors. The same result was noticed in the independent t-test for all variables compared to gender and colors. These showed colors did not play important role for measuring all variables among different methods.

Anova in sexes showed statistically significant difference (p<0.05) just for Intermolar width and Intercanine width. Alternatively this condition showed that sex dimorphisms played role.

Reliability test (Alpha Cronbach) for each method in measuring all the variables was used due to continuous data. According to Morgenstern, If alpha >0.8 shows that the variable has a good internal consistency. From table 2, all methods had the alpha value more than 0.8 for all variables.

The accuracy among methods could be seen in the sensitivity, specificity and ROC test of variables. Sensitivity >50% shows each variable is sensitive for methods of measurement. Specificity <50% shows each variable, individually, is not specific for methods of measurement. That means all variables should be gathered to give meaning for methods of measurement. The good value of ROC is >50%. All variables from table 3 showed value of ROC more than 50%.

Methods of measurement can be divided into 3D (1st, 2nd method) and 2D (3rd, 4th, 5th, 6th, 7th method). 3D method is considered accurate. Sliding Vernier Calipers is easier to find than digital calipers. That is why using sliding calipers is a Gold Standard for cast measurement.

With the concept of paperless office, and difficulty in storing the casts, there are ways of transforming casts into 2D form without losing the value. This research followed Paredes'suggestion of sitting the dental casts surrounded by a sheet of millimeter graph paper during the transformation, so that transformation dimension factors had the same numeric value as a mechanism of control.

From 2D methods, Photocopy machine and scanner could be used as means of transformation. 4th method of using digital calipers to measure the scanner result could cause error. 6th and 7th method would be the last option to be chosen for cast measurement.

To maintain the accuracy of measurement method, it is suggested to form mathematical equation to get a conversion value for each different variable from the gold standard. This mathematical equation derived from regression analysis applied for several variables that showed significantly different ($p<0.05$) as a result of different measurement methods compared to gold standard.

For example: to maintain the accuracy of 5th method, the mathematical equations derived from regression analysis are as follows:

Real value of 3.6	= -14.75741	+ 1.261582 x
Real value of 3.5	= -12.04128	+ 1.531466 x
Real value of 3.3	= -2.0347	+ 0.4251843 x
Real value of 4.2	= 3.439447	- 0.5525238 x
Real value of 4.5	= -4.755397	+0.6052776 x
Real value of MW	= -7.475684	+0.1593504 x

Note : x: the result of measurement gathered from 5th method

4. CONCLUSION

Colors did not play important role for the result of measurement gathered from different methods. Sexes should be considered taking part for different value of measurement.

3D measurement still gave the best measurement result, despite the difficulties in handling the dental casts. With some mathematical equations derived from regression analyses, 2D measurement could give almost the same result as 3D measurement.

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6. REFERENCES

[1] Hunter, WS, Priest, WR, Errors and Discrepancies in Measurement of tooth size , J. Dent Rest, 1960, 405-14.

[2] Shellhart, WC, Lange, DW, Reliability of the Bolton tooth-size analysis when applied to crowded dentitions, Angle Orthod. 1995; 5; 327-34.

[3] Sondhi, A, Cleall, JF, BeGole, EA, Dimensional Changes in the Dental Arches of Orthodontically treated cases; Am.J.Orthod.; 1980; 77(1): 60-74.

[4] Taner, T, Ciger, S, El, H, Germec, D, Es, T, Evaluation of Dental Arch Width and form changes after orthodontic treatment and retention with a new computerized method, Am.J.Orthod. Dentofacial Orthop., 2004; 126: 464-76.

[5] Noroozi, H, Djavid, GE, Moeinzad H, Teimouri, AP, Prediction of Arch Perimeter Changes due to orthodontic treatment., Am. J.Orthod. Dentofacial Orthop.; 2002; 122: 601-7.

[6] Braun, S, Hnat, WP, Fender, DE, Legan, HL, The Form of the Human Dental Arch, Angle Orthod; 1998; (1): 29-36.

[7] Zilberman, O, Huggare, JAV, Parikakis, KA, Evaluation of the validity of tooth size and arch width Measurements using Conventional and Three-dimensional Virtual Orthodontic Models, Angle Orthod., 2003; 73:301-6.

[8] Paredes, V, Gandia, JL, Cibrian, R, New, Fast, and Accurate Procedure to Calibrate a 2-Dimensional Digital Measurement Method, Am. J.Orthod Dentofacial Orthop 2005; 127:518-9.