Orthodontic Treatment Stability Assessment of Maxillary Arch Using Passive Self-Ligating and Conventional Brackets System in Adults Via Digital Calliper and Digital Dental Models: A Randomized Controlled Trial

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Abstract

The prime objectives of this study were to compare stability in incisor irregularity, intercanine width, interpremolar width, intermolar width, arch length, and arch depth after debonding and at six months of retention via laser scanned digital dental models (LSD) and digital calliper (DC).

This study was designed and conducted according to the Consolidated Standards of Reporting Trials (CONSORT) guidelines. The selected 47 orthodontic patients (age = 21.58 ± 2.94 years) were randomized into two groups to receive either a passive self-ligating (Damon® 3MX 0.022-in slot, n = 23) or a conventional system (Gemini MBT 0.022-in slot, n = 24). Dental models of each subject for maxillary arch were scanned via NextEngine laser scanner and ScanStudio HD software. The maxillary arch variables assessed via Laser scanned digital dental models (LSD) and Digital Calliper (DC) were measured.

The ICC coefficient values for inter-examiner were all in the range of strong correlation. Differences between the laser scanning and digital callipers measurements in most parameters were small except for the upper arch length at baseline and, none were statistically different.

The stability for maxillary incisor irregularity, intercanine width, interpremolar width, intermolar width, arch length, and arch depth after debonding and at six months of retention via laser scanned digital dental models (LSD) and digital calliper (DC) revealed no significant difference. Thus for orthodontic treatment stability assessment both digital calliper and 3D dental models can be used

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Introduction

Post orthodontic treatment stability is a continuous challenge to an orthodontist, it is mostly dependent on the patient compliance with removable retainers. Researchers evaluated the stability of occlusion after completion of treatment with the plaster dental models via digital callipers.[1,2] For orthodontic diagnosis and treatment planning, dental models has been used for various investigative purposes i.e tooth size discrepancy, mixed dentition, tooth size and arch dimension analysis and little irregularity index. Conventional calliper and digital dental models has been used for aforementioned measurements. Far reaching finding and treatment planning are fundamental in an effective orthodontic practice. Dental model analysis plays an important role aimed at dental model scrutiny, plaster cast has been the standard for years. In any case, plaster dental models has the inconvenience of misfortune, breakage, demolish and require pressing space in the dental clinics and hospitals.[3]

To control these disadvantages, advanced 3D digital dental models are a substitute to correspondence with patients and associates.[4,5] Digital dental models can be

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utilized for all intents and purposes with the benefit of clear point of interest at various amplifications and precise cross-sectional pictures for various measurements.[4,6] Three-dimensional dental models have undergone momentous improvements for various tooth size and arch dimensional related measurements.[7] The development leads to the computer-generated digital dental models of orthodontic patients and considered as a valid and reliable tool for various analysis in orthodontics.[8]

The current study conducted for mild to moderate crowding malocclusions between a passive self-ligating system (0.022-in slot; Damon® 3MX, Ormco, Orange, CA, USA) and a conventional system (0.022-in slot; Gemini MBT, 3M Unitek, Monrovia, CA, USA), using Hawley and vacuum-formed retainers. The prime objectives of this study were to compare stability in incisor irregularity, intercanine width, interpremolar width, intermolar width, arch length, and arch depth after debonding and at six months of retention via laser scanned digital dental models (LSD) and digital calliper (DC).

Material and Methods

All participants provided their written informed consent. Ethics approval was obtained from the Ethics Committee (DF OT 1005/0033[P]). This study was designed and conducted according to the Consolidated Standards of Reporting Trials (CONSORT) guidelines.[9] **(Figure 1)**.

Sample size calculation

To determine the sample size and power of the study, PS Sample Size Calculation Software (United States; http://biostat.mc.vanderbilt.edu/wiki/Main/ Power Sample Size) was used. At the significance level of 0.05 and power of study at 85%, to detect a clinically meaningful difference (incisor irregularity) of 2.0 mm[10-12] as clinically significant, the power analysis calculated that 19 patients in each group were sufficient with a ratio of 1:1. Therefore, a total sample size of 38 patients was required. To compensate for potential sample attrition during the follow-up studies, an additional 20% of patients were included. Total five hundred sixty variables were measured with the following inclusion and exclusion criteria.

Inclusion criteria. subjects treated only with a fixed orthodontic appliance using either the passive self-ligating or conventional system; comprehensive orthodontic treatment involving both arches; presenting with mild to moderate crowding malocclusions without the need for extraction; all permanent teeth erupted except for third molars, and no previous orthodontic treatment.

Exclusion criteria. prescribed single arch or sectional fixed appliance treatment, still growing (< 18 years old); presenting with congenitally missing teeth; poor periodontal status; craniofacial anomalies (e.g., cleft lip or palate patient); severe skeletal discrepancies requiring orthognathic surgery; severe crowding requiring extraction and spaced dentitions; Damage casts (voids or blebs on the plaster model obscuring the teeth or if the teeth on the models were fractured or missing); Teeth wear that affect the tooth size measurement; Missing or supernumerary teeth; Inter proximal caries or restoration

This randomized clinical trial comprised a two-arm parallel study with 1:1 allocation ratio. The selected 47 orthodontic patients (mean ± standard deviation [SD] age = 21.58 ± 2.94 years) were randomized into two groups to receive either a passive self-ligating (Damon® 3MX 0.022-in slot, n = 23) or a conventional system (Gemini MBT 0.022-in slot, n = 24). Thus the dental models were recruited from the subjects and processed for all variables measurements.

Fabrication of 3D Laser scanned digital dental models (LSD)

Dental models of each subject for maxillary arch were scanned via NextEngine laser scanner and ScanStudio HD software. First, the scanner collects surface data of the object by flash light, and then four laser beams slowly move across the surface of the object, capturing data points that form polygons which form the 3D geometric structure of the dental cast **(Figure 2)**. Laser scanned digital dental models (LSD) was proven as valid and reliable tool for such linear and angular measurements.[7,13] Data was collected from direct measurements of the final sample comprising 20 plaster study models and Laser scanned digital dental models (LSD) per appliance system group, using a calibrated digital caliper and NextEngine laser scanner (ScanStudio HD software). The maxillary arch variables assessed via Laser scanned digital dental models (LSD) and Digital Calliper (DC) were as follows:

Measurement via laser scanner Digital dental models and digital calliper.[2,8]

i) **Little's index of irregularity (IR):** the sum of the distances between the anatomic contact points from the mesial of the left canine to the mesial of the right canine **[Figure 3(a)]**.

ii) **Intercanine width (ICW):** the distance between cusp tips of the right and left canine. In cases of cusp attrition, the wear facet center was used **[Figure 3(b)]**.

iii) **First and second interpremolar width (1st and 2nd IPW):** the distance between the cusp tips of the right and left first and second premolars. In cases of cusp attrition, the wear facet center was used **[Figure 3(b)]**.

iv) **Intermolar width (IMW):** the distance between the mesiobuccal cusp tips of the right and left first molars. In cases of cusp attrition, the wear facet center was used **[Figure 3(b)]**.

v) **Arch length (AL):** the sum of the right and left distance between the midpoint of mesioincisal edges of central incisors to the mesiobuccal cusp tips of the right and left first molars **[Figure 4 (a)]**.

vi) **Arch depth (AD):** the distance measured from the midway point between the mesioincisal edges of the central incisors and the point bisecting the line connecting the mesiobuccal edges of the cusp tips of the right and left first molars **[Figure 4(b)]**.

Statistical analysis

Reliability of the measurement were statistically assessed using Inter-class correlation coefficient (ICC). To test the reliability of the method, one examiner (N.A.R) measured all variables on eight randomly selected models and repeated those measurements 2 weeks later both via LSD and DC. Measurements were also repeated by a second examiner (F.S) on the same orthodontic models that had been measured by the first examiner. Inter-observer reliability coefficients were then calculated. Histograms were visually inspected for assessment of data normality. Skewness and kurtosis testing were further utilized in order to evaluate the amount and direction of histograms relative to a standard bell curve. The distribution of the data was found to be skewed for incisor irregularity but was normally distributed for the arch dimensions. The median and the interquartile range were therefore calculated for the skewed variables, while mean and SD were determined for variables that were normally distributed. Comparison of the measurements between the two methods was carried out using paired t-test.

Results

Tables **1** and **2** show the Inter examiner reliability for LSD and DC measurements respectively. The ICC coefficient values for inter-examiner (N.A.R) and (F.S) were all in the range of strong correlation (7). All ICC coefficient values were statistically significant ($p<0.001$).

This study included 40 subjects with mean age 21.6 years and there were more females (60%) than male subjects (40%) (Table 3). Equal number of subjects had received the conventional and self-ligation brackets and were prescribed with Hawley and vacuum-formed retainers.

The result of analysis for the upper arch is presented in Table 4. Differences between the laser scanning and digital callipers measurements in most parameters were small except for the upper arch length at baseline and, none were statistically different.

Discussion

Previous researches has established that digital dental models and digital software are proficient of authentically mimicking dental topographies with a high degree of accuracy.[7,13,14] Orthodontist currently using the digital dental models and advance software in there clinical practice for keeping patient digital record. Favourable position of utilizing explanatory digital dental models programming is that the computer can give an outcome rapidly. For the tooth size analysis digital measurements can reduce the errors as occurred via conventional plaster dental models.[15]

A survey proved that the use of digital dental models in orthodontic practices has amplified among eighteen percent of practitioners in the United States.[16] However, the current trend for the digital dental models is low in Malaysia. This progress has been impelled by an assortment of apparent benefits comprising compact storage requirements; quick access to digital evidence; easy transmission of data; adaptability; and monetary savings.[14,16-18] Direct measurement on plaster dental models is unavoidably associated with some degree of imprecision. To produce a more accurate gold standard, researchers have produced digital dental models allowing more precise measurement[5,7,13] and have equated digital and plaster dental models for various tooth size and arch dimension. Mostly, digital models with more accuracy using these methods.[8] Due to current advancement in the direct digital superimposition methods and digital point recognition, digital dental modelling replaced plaster models as the gold standard.[16]

The use of digital dental models has an interest to may researchers as the retrieval is fast and efficient, no physical damage and comprehend at multiple locations.[7,14,17-20] Researcher used the digital dental models for various orthodontic fact-finding measurements, such as mixed dentition analysis, tooth size discrepancies, tooth size, crowding or spacing, overjet and overbite.[21,22] The post orthodontic treatment patient satisfaction were investigated via various scales[23] The biology of tooth relapse after the success of orthodontic treatment is not yet known however, treatment stability were also observed via application of supplemental medication.[24]

There is scarcity in the use of digital dental models in Malaysian orthodontic clinic and dental hospitals. The current study was performed for the comparison of the LSD and DC measurements modalities to assess and compare the stability in both systems for incisor irregularity, ICW, 1st IPW, 2nd IPW, IMW, AL and AD variables. However no significant difference were observed between two measurements modalities. The findings of this study demonstrate that the treatment stability of the self-ligating system in terms of occlusal changes, incisor irregularity and arch dimensions, from debonding and at 6-month retention period was comparable to that of a conventional system via LSD and DC. However, for various variables measurements an adequate calibration of the examiners is essential to achieve repeatability in both methods. For diagnosis, treatment planning and various analytical measurements 3D digital dental models might be acceptable.

Conclusions

The stability for maxillary incisor irregularity, intercanine width, interpremolar width, intermolar width, arch length, and arch depth after debonding and at six months of retention via laser scanned digital dental models (LSD) and digital calliper (DC) revealed no significant difference. Thus for orthodontic treatment stability assessment both digital calliper and 3D dental models can be used.

Conflict of Interest

The authors state that there were no conflicts of interest related to this study.

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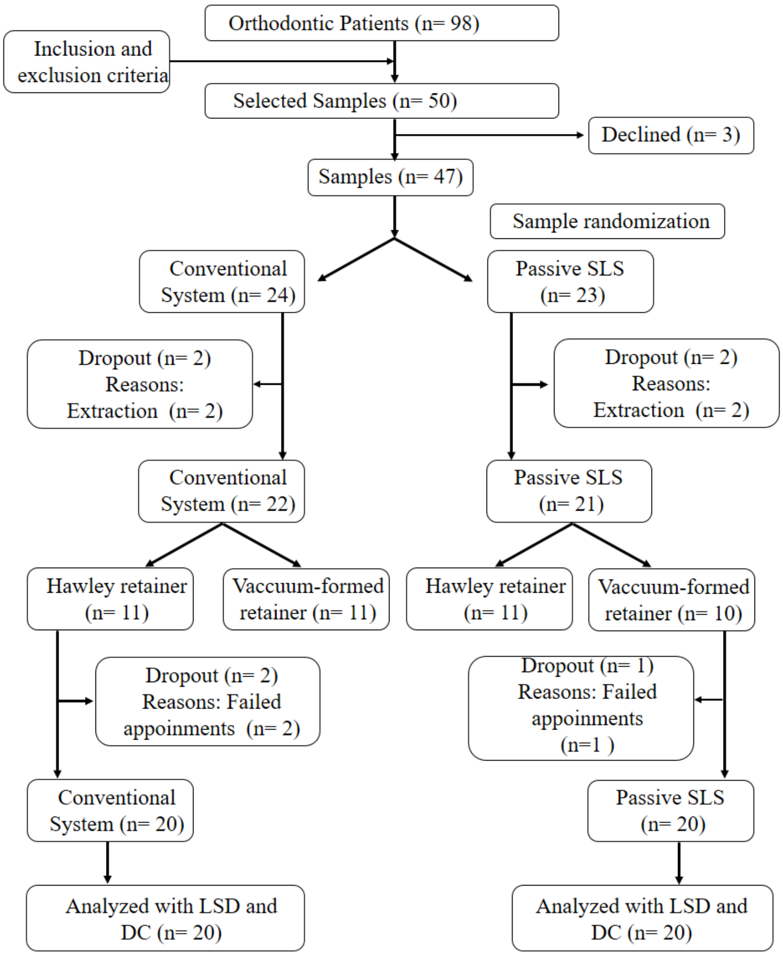

Figure 1. CONSORT flowchart of the study.

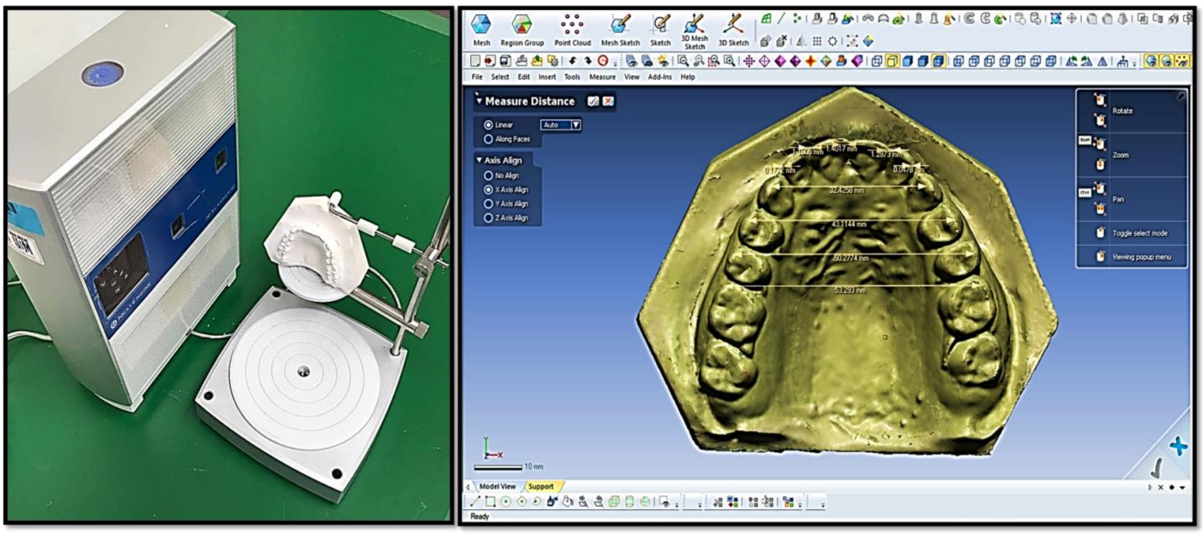

Figure 2. NextEngine laser scanner fabricated digital dental models.

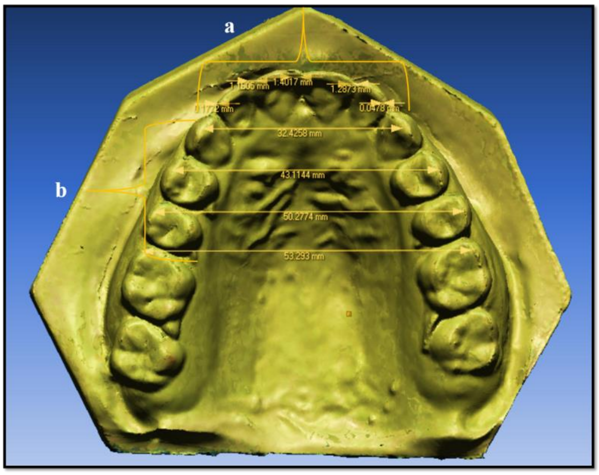

Figure 3. Measurement via digital dental models: Little's index of irregularity, (b): Intercanine width, first and second interpremolar width, Intermolar width.

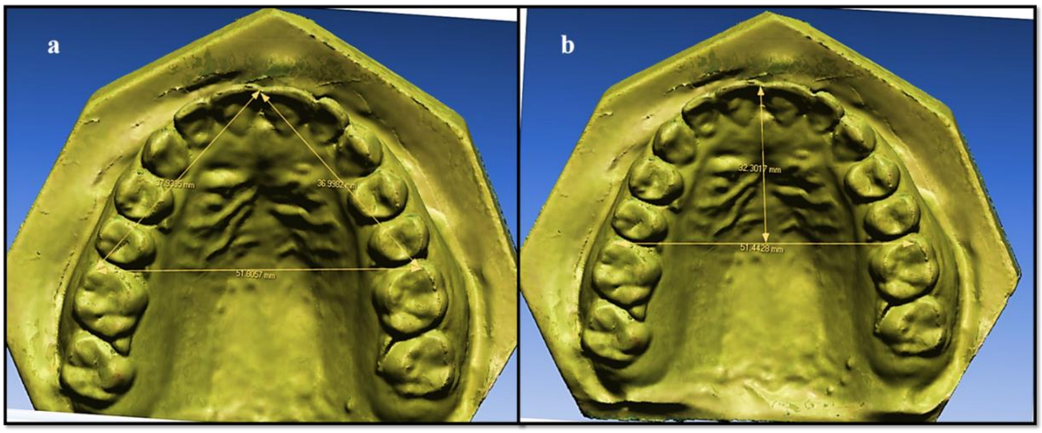

Figure 4. (a): Measurement of Arch length and (b): Arch depth.

Variables	R1	R2	Coefficient	P
DC	LIR1	LIR2	.917	.002
	ICW1	ICW2	.989	.0001
	IPW11	IPW12	1.000	.0001
	IPW21	IPW22	1.000	.0001
	IMW1	IMW2	1.000	.0001
	AL1	AL2	1.000	.0001
	AD1	AD2	1.000	.0001
LSD	LIR1	LIR2	.989	.0001
	ICW1	ICW2	.987	.0001
	IPW11	IPW12	1.000	.0001
	IPW21	IPW22	1.000	.0001
	IMW1	IMW2	1.000	.0001
	AL1	AL2	1.000	.0001
	AD1	AD2	1.000	.0001

Table 1. Inter-examiner reliability for T0 stage LSD and DC [a] T0, after debonding; DC, Digital Calliper; LSD, Laser scanned digital dental models; R1, Reading 1; R2, Reading 2; LIR, Little's index of irregularity; ICW, Intercanine width; IPW1, First interpremolar width; IPW2, second interpremolar width; IMW, Intermolar width; AL, Arch length; AD, Arch depth, [a], Intra class correlation; P; P value (<0.05).

Variables	R1	R2	Coefficient	P
	LIRI1	LIR2	1.000	.0001
	ICW1	ICW2	1.000	.0001
	IPW11	IPW12	1.000	.0001
DC	IPW21	IPW22	1.000	.0001
	IMW1	IMW2	1.000	.0001
	AL1	AL2	1.000	.0001
	AD1	AD2	1.000	.0001
	IRI1	IRI2	1.000	.0001
	ICW1	ICW2	1.000	.0001
	IPW11	IPW12	1.000	.0001
LSD	IPW21	IPW22	1.000	.0001
	IMW1	IMW2	1.000	.0001
	AL1	AL2	1.000	.0001
	AD1	AD2	1.000	.0001

Table 2. Inter-examiner reliability for T2 stage LSD and DC side [a] N, number; SD, standard deviation; %, percentage. T2, after six months of debonding; DC, Digital Calliper; LSD, Laser scanned digital dental models; R1, Reading 1; R2, Reading 2; LIR, Little's index of irregularity; ICW, Intercanine width; IPW1, First interpremolar width; IPW2, second interpremolar width; IMW, Intermolar width; AL, Arch length; AD, Arch depth, [a], Inter class correlation; P; P value (<0.05).

Variables		**N (%)**
Age, Mean (SD)		21.6 (2.94)
Sex	Male	16 (40.0)
	Female	24 (60.0)
Brackets	Conventional	20 (50.0)
	Self-ligation	20 (50.0)
Retainers	Hawley	20 (50.0)
	Vacuum-formed	20 (50.0)

Table 3. Descriptive statistics of the sample in the study (N=40). N, number; SD, standard deviation; %, percentage.

Baseline	LSD Mean (SD)	DC Mean (SD)	Difference Mean (SE)	p
LIR	0.00 (0.031)	0.01 (0.027)	-0.01 (0.005)	0.3
ICW	36.21 (1.728)	36.17 (1.697)	0.04 (0.031)	0.3
IPW1	45.09 (1.495)	45.05 (1.447)	0.04 (0.086)	0.7
IPW2	50.12 (1.739)	50.15 (1.801)	-0.02 (0.062)	0.7
IMW	53.26 (2.465)	53.28 (2.460)	-0.03 (0.026)	0.3
AL	67.26 (3.956)	67.66 (3.829)	-0.40 (0.359)	0.3
AD	24.69 (2.064)	24.72 (2.068)	-0.02 (0.035)	0.7
After 6 months				
LIR	0.28 (0.553)	0.29 (0.550)	-0.01 (0.010)	0.8
ICW	36.33 (1.601)	36.32 (1.581)	0.02 (0.042)	0.7
IPW1	44.97 (1.475)	44.94 (1.461)	0.03 (0.027)	0.2
IPW2	50.06 (1.819)	50.06 (1.822)	0.00 (0.033)	0.9
IMW	53.15 (2.596)	53.14 (2.605)	0.01 (0.010)	0.8
AL	67.25 (3.571)	67.23 (3.534)	0.02 (0.062)	0.7
AD	24.91 (1.828)	24.96 (1.870)	-0.06 (0.049)	0.2

Table 4. Differences between the LSD and DC measurements of landmarks for upper arch (mm) (N=40) [a]. DC, Digital Calliper; LSD, Laser scanned digital dental models; R1, Reading 1; R2, Reading 2; LIR, Little's index of irregularity; ICW, Intercanine width; IPW1, First interpremolar width; IPW2, second interpremolar width; IMW, Intermolar width; AL, Arch length; AD, Arch depth, [a], paired t-test; SE, standard error; SD, standard deviation; P; P value.

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