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A Comparative Study to Evaluate the Effectiveness of 3D Digital Models and Study Cast to Measure Anteroposterior Anchorage Loss in Patients Treated with Preadjusted Edgewise Appliance

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Abstract

Anchorage loss is an important parameter in controlling the outcome of orthodontic treatment. Lateral cephalogram and study model analysis are routinely used to monitor anchorage loss. Study is to evaluate the effectiveness of 3D digital model and study cast to measure maxillary molar anchorage loss in patients treated with fixed orthodontic appliance. A total of 31 high anchorage patients who were treated with pre adjusted edgewise appliance for their malocclusions were included in the study. Amount of horizontal anchorage loss was measured by two methods: Study cast and 3D digital model super imposition. The anterior palatal rugae area was taken as a reference point for comparative measurements. Paired t-test was performed to compare the mean values of anchorage loss measured on both methods. When we compared the mean anchorage loss of two methods, it was found that there were no statistically significant differences observed for both the right side ($t= 0.513$, $p>0.05$) and left side ($t= -0.081$, $p>0.05$). The spearman correlation between two methods showed a very strong correlation in both right ($r=0.919$) and left side ($r=0.906$) which was statistically significant ($p <0.001$). The present study shows that the measurement of anchorage loss using 3D digital superimpositions is equally reliable as that of study models. Thus, 3D digital models present as an alternative method to the measurement of anteroposterior anchorage loss.

Keywords: Anchorage Loss, Fixed Orthodontics, 3D Digital Models, Study Cast

1. Introduction

Orthodontic treatment involves substantial forces for retraction and aligning teeth. These forces generate opposite reciprocal forces of the same magnitude resulting in anchorage loss. Anchorage loss is a potential cause for failure of orthodontic mechanotherapy[1]. The extracted tooth position, additional appliance, age of the patient, degree of crowding and over jet determines the anchorage loss. Planning anchorage control with adequate intra or extra oral anchorage devices such as Trans-Palatal Arch (TPA), Nance appliance, involvement of multiple teeth as anchorage segment, extra oral and skeletal anchorage system will resist or stabilize the molar position[2].

Measurement of anchorage loss at every stage of treatment can help the orthodontist to achieve the planned treatment objectives. Measurement of anchorage loss is commonly done on cephalometric superimposition and study cast measurement, has been considered the reliable methods to determine the movement of teeth with respect to stable reference points[3]. Superimposition of cephalometric radiographs requires multiple radiation

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exposures, distortion due to different magnification and many clinicians desist from routinely using this method[4].

Study models have been used as a most accepted method of anchorage loss. But they have many disadvantages such as likelihood of infection, can wear away plaster which leads to losing of anatomical details of the cast thus decreasing accuracy, study models can break, storage needs space[5]. During stage record, making impression for study cast is difficult as the impression material can tear and also dislodge the orthodontic brackets. An alternative method using an intraoral scanner and producing Three-Dimensional (3D) digital models is gaining popularity.

3D digital models' usage is increasing because of its convenience. Continuous development of 3D digital laser scanner and software technology leads to very accurate transformation of scanned data into images. Superimposition of 3D virtual models can offer more detailed information on orthodontic tooth movement in comparison with traditional two-dimensional cephalometric analysis[6,7].

Digital orthodontic record systems with integrated digital photos and radiographic records are replacing stone study casts with 3D digital models[8–10]. So, the present study was formulated to evaluate the effectiveness of 3D scanning and study cast to measure anteroposterior anchorage loss in patients treated with pre adjusted edgewise appliance.

2. Materials and Methods

The current research compared the effectiveness of two different methods in measuring anteroposterior anchorage loss in patients treated with pre-adjusted edgewise appliance. Records of 31 maximum anchorage patients (16 males, 15 females; mean 18.54±7.8 years) with Class II division 1 malocclusion treated in the Department of preventive dentistry, Ibn Sina National College Dental Hospital were included in the study. The study was approved by the institutional review board (Ethical committee approval no H-16-11072019). Consent of the patients were obtained after being informed that their records might be anonymously used for research purpose at later stage.

Depending upon the degree of the malocclusion, patterns of orthodontic tooth movement can vary. A minimum age of treatment as 18 years for male patients and 14 years for female patients was fixed to minimize the post treatment growth effect.

The fixed orthodontic treatment started with 0.022" × 0.028" bracket slot dimension of MBT prescription. Maxillary second molars were banded and included to increase the posterior anchorage. Consequently, the arches were aligned and leveled with 0.019" x 0.025" Stainless Steel wire. Alignment was considered to be complete and recorded after 6 weeks without any active force. Post-alignment records (3D digital model and Study cast) were taken at this stage. Pretreatment and post alignment records were analyzed and amount of Anteroposterior anchorage loss measured in millimeters.

To calculate the amount of horizontal anchorage loss an acrylic palatal jig was fabricated on the pretreatment study model. The anterior palatal vault (rugae area) was used as a reference point for the placement for the palatal jig. The acrylic jig was fabricated with reference wires (0.045 stainless steel) embedded that extended to the mesial fossa of first molars[4,11]. The acrylic jig was constructed for every patient using the pre-treatment model (Figure 1).

Figure 1. Fabrication of palatal acrylic jig for measurement of horizontal molar movement on cast.

The pretreatment model was used to fabricate the jig which was then fitted on the stable reference point i.e., palatal rugae on the final model after completion of alignment. The distance between the initial positions of the wire to the final position was measured at the molar region with the help of Vernier calipers to calculate the molar anchorage loss in each subject.

3D digital models were acquired at pre- and post-treatment using a 3D laser scanning system (Stratasys D900L 3D scanner). The accuracy of the models were ± 0.02 mm for 10 mm and a resolution of 1,024 × 768 pixels.

Using Rapid form 2006 software (INUS Technology, Seoul, Korea) 3D surface-to-surface matching with medial end of 3rd rugae as a reference point was performed (Figure 2).

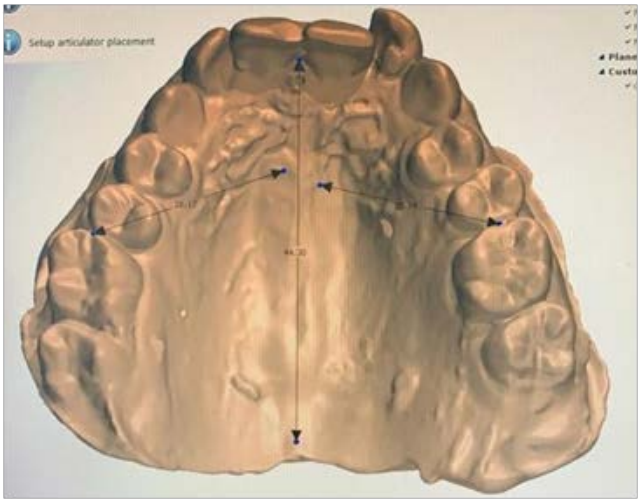

Figure 2. Pretreatment digitalized cast with reference points & measurement of linear variable.

3. Statistics

Statistical differences between two groups were analyzed with Independent student's 't' test. Spearman's correlation test was used to analyze degree of correlation between study cast and 3D digital casts measuring anchorage loss.

4. Results

A total of 31 samples were analyzed for two methods of measurement a) study cast and b) 3D superimposition. The mean anchorage loss in the study cast was found to be 3.56 ± 1.22 for the right side and 3.47 ± 1.19 for the left side. When the right-side 3D Superimposition showed a mean anchorage loss of 3.52 ± 1.13, the left side had a mean value of 3.48 ± 1.14 (Table 1).

When we compared the mean anchorage loss of two methods, there were no statistically significant differences observed for both groups, right side (t = 0.513, p>0.05) and left side (t = -0.081, p>0.05) (Table 2). The spearman correlation between two methods showed a very strong correlation in both right (r = 0.919) (Figure 3) and left side (r = 0.906) (Figure 4) which was statistically significant, p <0.001 (Table 3).

5. Discussion

Study models provide a permanent record of a patient's malocclusion, useful to discuss proposed treatment plan with patients and to visualize the treatment process. Study models can also be useful for helping to monitor the results of patient's treatment during follow-up visits. In Clinical orthodontic practice, diagnostic measurements have been traditionally made on plaster dental casts. Storage of study models is problematic in terms of space constraints and cost. The application of three-dimensional imaging is becoming more accessible and practical. The various applications of 3D technology in the field of orthodontics have allowed for advances in diagnosis, treatment planning, and orthodontic techniques. Superimpositions of these images provide a comparison to established norms and templates, the determination of changes resulting from treatment or growth, as well as a prediction of potential treatment outcomes[12].

Many software programs are available to perform 3D superimpositions. Each of these different methods, techniques, and software differ in their ease of use, efficiency, accuracy, time required, and cost. With the use of 3D superimpositions being relatively new to the field of orthodontics, its potential for use in the research and clinical settings is still in its early stages. As technology and techniques improve, registration of 3D images will become faster, easier, and more efficient to help transform

Table 1. Mean of two methods

		N	Mean	Std. Deviation	Minimum	Maximum
STUDY CAST WITH ACRYLIC JIG	RIGHT	31	3.565	1.222	1.470	5.980
	LEFT	31	3.475	1.197	1.520	6.430
STUDYCAST 3D SUPERIMPOSITION	RIGHT	31	3.521	1.128	1.370	5.650
	LEFT	31	3.483	1.141	1.260	5.440

Table 2. Comparison of two methods

	Mean difference	SD	Std. Error Mean	95% Confidence Interval of the Difference		't' value	P value*
				Lower	Upper		
STUDY CAST WITH ACRYLIC JIG RIGHT VS STUDYCAST 3D SUPERIMPOSITION RIGHT	.04419	.48032	.08627	-.13199	.22038	.512	0.612 (NS)
STUDY CAST WITH ACRYLIC JIG LEFT VS STUDYCAST 3D SUPERIMPOSITION LEFT	-.00742	.50891	.09140	-.19409	.17925	-.081	0.936 (NS)

*P value ≤ 0.05 is considered statistically significant

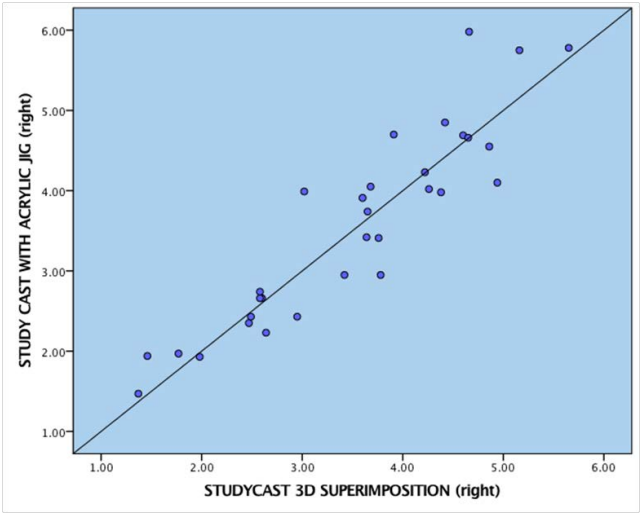

Figure 3. Correlation between study cast acrylic jig and study cast 3D superimposition (Right).

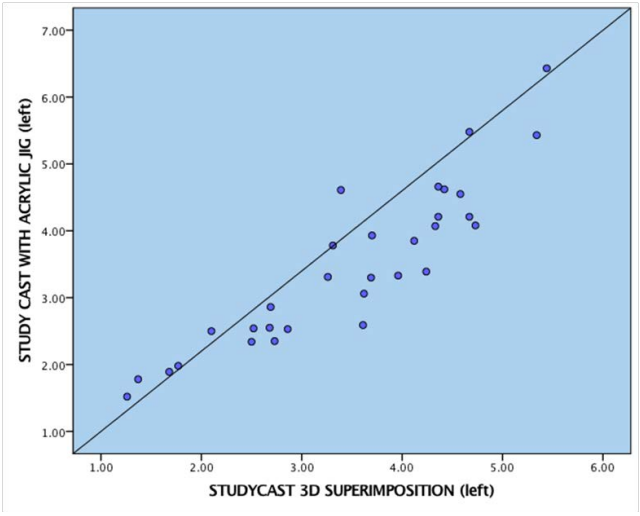

Figure 4. Correlation between study cast acrylic jig and study cast 3D superimposition (Left).

Table 3. Correlations

	N	Spearman Correlation	P value
STUDY CAST WITH ACRYLIC JIG RIGHT ***VS*** STUDYCAST 3D SUPERIMPOSITION RIGHT	31	.919	<0.001
STUDY CAST WITH ACRYLIC JIG LEFT ***VS*** STUDYCAST 3D SUPERIMPOSITION LEFT	31	.906	<0.001

*P value ≤ 0.05 is considered statistically significant

and advance the way orthodontists diagnose and treat patients[13].

Intraoral scanning is faster, reduces patient discomfort, and simplifies the impression procedures for the dentist, eliminating plaster models and cross contamination. Digital models allow better communication with the dental technician and also explaining the treatment with the patients. Intra oral scanners are not very accurate in crowded teeth, there is a steep learning curve with high initial costs of setup[14]. In comparative studies, intra oral optical scanner was less accurate than model scanning which implies that the intraoral conditions (saliva, limited spacing) may contribute to the inaccuracy of a scan[15,16].

Digital models can be easily stored, can be transferred electronically to colleagues, specialists, and insurance companies. They are also an excellent tool for patient education[17]. The present digital generation can be more comfortable with computer-generated images. Digital models can be manipulated to show the possible future treatment outcomes in malocclusion to the patient and their parents during pre-treatmentdiscussion[18].

For fabrication of crowns and short fixed partial dentures, digital impression techniques are becoming more acceptable[19]. Currently, intraoral scans are time consuming. In a clinical study of comparing chair side impressions and digital scanning, 73.3% of patients preferred impressions because that was faster. 26.7% preferred the scan because it was "more comfortable. With digital technology continuous to progress, intraoral scanning is gaining more acceptance among orthodontic clinicians[20,21].

6. Conclusion

There was no statistically significant difference in the quantum of anchor loss between 3D virtual models' system and Conventional study casts. Considering that 3D digital models are efficient in planning, reducing discomfort and increased treatment efficacy, they are effective tools to measure anchorage loss in fixed orthodontic patients.

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