Comparison of mesio-distal dimensions of teeth as measured on study models and their photographs

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Abstract

Introduction: Orthodontics, like many other areas of life, is going digital. Many orthodontists are joining other health professionals in using paperless patient information systems that include virtual chart notes and health histories, and digital photographs and radiographs. However, a major obstacle for orthodontists is the necessity of plaster study models of a patient's dentition for treatment planning. The introduction of modern computer-based orthodontic record systems with integrated digital photos and radiographic pictures will probably lead to the replacement of plaster casts with virtual digital models in the near future. The objective of this study was to compare the mesio-distal width of the teeth as measured on standard plaster study models and their photographs.

Methods: Alginate impressions of maxillary arch of 15 subjects were taken and poured in dental stone. The mesio-distal width of all the teeth from right second molar to left second molar were measured with the help of an analog caliper to the nearest 0.5mm on the study models. The photographs of the occlusal view of the study models were taken with a scale placed on the left side of the plaster model for calibration. These photographs were transferred to Nemotec software. The mesio-distal width of the same teeth as measured on study models were recorded on their photographs using Nemotec Software. A single factor ANOVA was used to compare reliability and validity of mesio-distal width of the teeth as measured on the study models and their photographs.

Results: There was no statistically significant difference between the mesio-distal width of the teeth as measured on study models and their occlusal photographs.

Conclusion: The results indicate a similarity between photographic and physical measurements thus indicating that photographic records can serve as an alternative to study models. This might help in eliminating the need for storage of plaster models as well as eliminate the risk of breakage of study models during storage. Storage of models in the electronic format will also allow for exchange of information between fellow orthodontists and eliminate any errors arising due to breakage of study models.

Keywords: Digital plaster models, comparison, photographs of plaster models.

Introduction

Orthodontics is also going paperless like many other health professions and using patient information systems that include virtual chart notes, health histories, digital photographs and radiographs. Digital imaging of study models has emerged as one of the most important aspect of diagnosis and treatment of orthodontic cases. The classical orthodontic patient documentation comprises of lateral cephalograph, ortho-pentamograph, intra-oral and extra-oral facial photographs and plaster study models. Tooth size, arch length discrepancies, over jet and overbite are routinely measured and recorded on plaster study models. This physical assessment has been a barrier for orthodontists in going fully digital in their profession. The introduction of modern computer-based orthodontic record systems with integrated digital photos and radiographic pictures will probably lead to the replacement of plaster casts with virtual digital models in the near future. Digital models can also be obtained chair-side by use of intra-oral camera based on structured light principle. Various systems have been developed to address this factor and in late 1999, Ortho CAD (Cadent, Carlstadt, NJ) developed virtual digital dental casts. Then, in early 2001, e-models (Geo Digm, Chanhassen, Minn) came to market[1]. The technology of digital study models allows an orthodontist to send a patient's alginate impression or existing plaster study model to these companies for processing into a virtual 3-dimensional (3D) computerized image. This image is then available to the orthodontist for downloading from the company's web-site within 5 days. Software from the imaging companies allows the orthodontist to view the image and manage it in a virtual 3D environment. The first method has disadvantages in terms of dependency on lab for processing the models along with added cost involved. The intra oral scanners used chair-side are also expensive and require additional software for processing the models. Therefore need of simple, practical and inexpensive method for obtaining digital models that could be used for various model analysis using Nemotech software, already being used for cephalometric analysis in the department was the baseline of idea for this study.

Considering this, it was decided to take occlusal photograph of plaster models to digitize them (2-D images) using armamentarium and software routinely utilized for taking orthodontic records in the department and to analyze the reliability and reproducibility of this method and physical measurements of tooth size on plaster models.

Material and Methods

Alginate impressions of maxillary arch of 15 subjects were taken and poured in dental stone. The study models thus obtained had to completely reproduce the soft and hard tissues which show no surface marks, no loss of tooth structure, voids or fractures and demonstrate varying degrees of contact point and buccolingual tooth displacements. The mesio-distal width of all the teeth from right second molar to left second molar were measured with the help of an analog caliper to the nearest 0.5mm on the study models[2] (Fig.1). The greatest mesio-distal width of each tooth was measured at the contact areas. These measurements were noted as physical measurements of the teeth. The photographs of the occlusal view of the study models were taken using a Canon 600D DSLR routinely used for taking patient's photographs. The scale was placed on the right side of the plaster model for calibration while taking the photographs (Fig 2). These photographs were transferred to Nemotec software and magnification error was eliminated using calibration tool of the software. After calibration, mesial and distal contact points were marked from right second molar to left second molar and mesio-distal width was measured as the distance between them (Fig 3). All measurements were recorded in a Microsoft Excel 2000 spreadsheet and analyzed with SPSS version 11.5. A single factor ANOVA was used to compare reliability and validity of mesio-distal width of

the teeth as measured on the study models and their corresponding photographs.

Result

The mean physical and photographic mesio-distal measurements of central and lateral incisors, canines, first premolars, first and second molars showed a statistically non-significant difference ($p>0.05$) (Graph 1), where as mesio-distal measurement of second premolars yielded a statistically significant difference ($p<0.01$) (Graph 2).

Discussion

Study models are a reliable and essential part of diagnostic record since they are dimentionally accurate representation of the dentition. A number of measurements and analysis such as tooth size arch length discrepancy and prediction of permanent tooth size can be obtained from plaster study models.

Digital models on the other hand, eliminate many of the obstacles encountered with plaster models. They are not subjected to physical impairement and do not produce any dust. Also they do not require physical storage space. Retrieval is quick and efficient and are an excellent tool to educate the patient. Storage of models in the electronic format will also allow for exchange of information between fellow orthodontists and eliminate any errors arising due to breakage of study models. Digital models created either by direct or indirect method are expensive and require extra armamentarium. The direct method for creation of virtual models are either the direct scan of the dentition by and intra-oral scanner using structured light or radiographic data such as CBCT, MRI, CT. An indirect method as the name suggests, requires additional steps, such as taking impression, pouring of the models in plaster before it is captured in digital format. The scanning of an impression or plaster cast can be done by a laser, structured light or even radiographic methods. The application of digital models in orthodontic practice is in full swing. Several studies had been conducted to compare the reliability and validity of tooth size measurements done on plaster study model and virtual study model obtained by direct or indirect technique. In a study by Lee and Cangialosi[3], statistically significant but not clinically relevant differences were detected on comparison of measurements done on plaster models and digital models derived form CBCT scans. Study by Keating et al[4] found statistically non-significant differences between measurements made directly on plaster models and 3D models obtained by optical laser scanning device. Schirmer and Wiltshire[5] in their study had regarded a measurement difference between alternative methods of less than 0.20m as clinically acceptable.

If virtual model can be fabricated with low cost armamentarium or with equipments already used in dental clinics for orthodontic records, then both time and money can be saved, making it an economical alternative to various direct and indirect technique of fabricating digital models. Thus we decided to digitize plaster models with DSLR camera and Nemotech software and compared the mesio-distal tooth size of digital models with physical measurements of plaster models.

The results of our study showed a good association between the mesio-distal width of teeth on plaster model and photographs of occlusal view except for the second premolar where a statistically significant difference was seen. This suggests that digitization of plaster models with routinely used armamentarium will be cost effective and can be done easily with no dependency on external assistance. The significant difference in mesio-distal width of premolar between the digital and plaster model could be because of rotations commonly observed in this tooth and this could be eliminated by measuring mesio-distal width on other views of plaster model and conducting the study on a larger sample size so as to see whether this finding was by chance or not. The result of our study was similar to the study by Stevens et al[1] who compared the mesio-distal width of teeth on plaster models with their digital counterparts made with emodel software and found non-significant difference between the two measurements.

Within the limitation of our study, we can say taking the occlusal photograph of the model and transferring it to Nemotech or any cephalometric analysis software has promising avenues for digitization of plaster models. Further studies should be conducted on a larger sample size and reliability of various model analysis must be evaluated for these digital models.

Conclusion

The digitization of the plaster model by taking the occlusal photograph and transferring it to computer software can serve as an alternative to plaster study models.

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Fig. 1 Physical Measurement

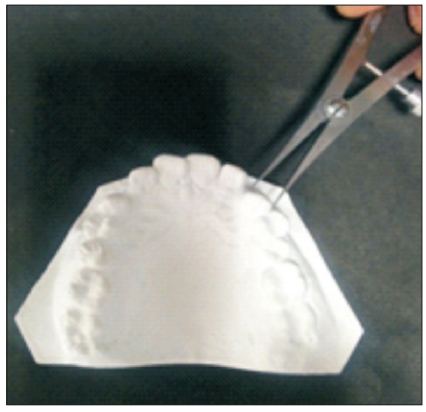


Fig. 2 Occlusal Photograph of Plaster Model of Plaster Model

Fig. 3 Mesio-Distal Measurement of Teeth on Oclusal Photograph using Nemotech Software

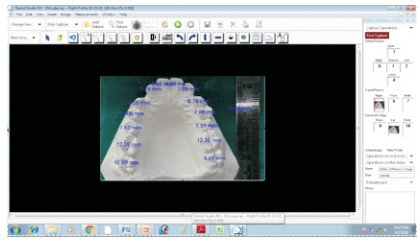
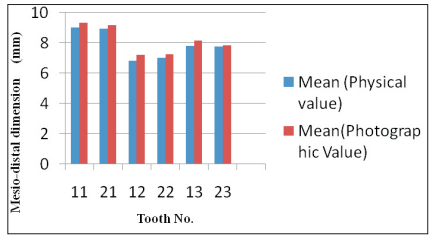


Table 1 - Comparison of Physical and Digital Mesio-Distal Measurements of Teeth

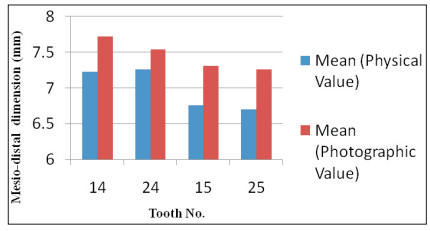
Tooth No.	Physical Value		Photographic Value		P-Value
	Mean	SD	Mean	SD	
11	9.0	...	9.33	±0.61	0.20
21	8.93	±0.75	9.18	±0.55	0.30
12	6.83	± 0.48	7.22	±0.57	0.10
22	7.0	±0.50	7.24	±0.53	0.20
13	7.80	±0.64	8.14	±0.74	0.18
23	7.76	±0.45	7.86	±0.71	0.67
14	7.23	±0.45	7.72	±0.65	0.08
24	7.26	±0.53	7.54	±0.60	0.19
15	6.76	±0.45	7.31	±0.57	0.007*
25	6.70	±0.49	7.26	±0.47	0.003*
16	10.43	±0.53	10.80	±0.74	0.13
26	10.50	±0.80	10.89	±1.12	0.27
17	9.70	±0.77	9.96	±0.89	0.40
27	9.90	±0.78	9.96	±0.93	0.85

* p<0.01 – significant

Graph 1 Mean Physical and Photographic Value of Cental, Lateral Incisors and Canines



Graph 2 - Mean Physical and Photographic Value of First and Second Premolars



Graph 3 - Mean Physical and Photographic Value of First and Second Premolars