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ORIGINAL ARTICLE

COMPARISON OF PALATAL VAULT DEPTH ON PLASTER VERSUS DIGITAL MODELS

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ABSTRACT

Objective: *The aim of the study was to compare the palatal vault depth on the digital scanned models versus plaster models.*

Methodology: *In this Cross-sectional comparative study, thirty plaster models were selected for recording measurements. Palatal depth was recorded manually on plaster models with digital calipers and the same measurements were repeated on their scanned digital versions obtained with Carestream Scan Flow, using distance measuring tool. Two examiners independently recorded the measurements.*

Results: *The difference between the manual and digital methods was statistically insignificant (p=.074), for palatal vault depth measurement at the molar region. Although statistically significant (p=.001), palatal vault depth difference between the two methods, at the inter canine area was of small magnitude to have any clinical significance. Inter observer and intra observer reliability was reasonably good (r>.75). The gender wise differences between the all the measurements were insignificant. For palatal vault depth on digital models at the intermolar region the difference was insignificant (p= .83) and similarly on plaster models, palatal vault depth at the intermolar region was also statistically insignificant (p= .92).*

Conclusion: *The reliability and reproducibility of digital models was good enough to provide a satisfactory alternate for plaster models in recording measurements like palatal vault depth in clinical settings.*

Keywords: *Orthodontics, digital models, dental casts, intra-oral scanner.*

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INTRODUCTION

For diagnosis and treatment planning in orthodontics, base line records like dental casts are quite essential.[1] Dental casts help to visualize the position of teeth in the arch and their morphology. In addition to classifying malocclusions, dental casts help us to identify anomalies, perform trial set ups and to prioritize the treatment objectives.[2]

The storage and retrieval of plaster models is rather problematic.[3] In addition to this, plaster models are bulky and are prone to damage during manipulation and recording measurements, which can be difficult and time consuming. Retention of patient records like radiographs and dental casts is essential in orthodontics. This creates storage problems prompting the search for alternative methods of obtaining and storing orthodontic records.[1,4]

Study models can now be digitized and stored in computer memory owing to the advances in technology. Digital models can be measured with software tools and saved, retrieved and shared electronically with a computer. They can be viewed three-dimensionally on a computer. Digitization of models also provide the benefit of greater productivity.[4]

With the advent of intra oral scanners obtaining digital models, life has been made easier for the clinician. The

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hassle of dispensing the correct ratio of water and powder and pouring impressions in dental stone can now be easily averted. Dental casts require physical space and suitable conditions for storage. This could be rather difficult in clinical settings with large patient influx.[4]

Intra oral scans of the arches provide digital casts which help in diagnosis and treatment planning. Numerous studies have been conducted to evaluate the accuracy of intraoral scans and digital models.[5,6] Warnecki et al[7] conducted a meta-analysis to study the reliability and accuracy of measurements on scanned digital casts and plaster models. They found no statistically significant differences between the measurements. However, majority of the studies have focused on the intraoral scanning of dental hard tissue.[8,9] However, intraoral scans have shown discrepancies in the distal end of the arch, interproximal surfaces and the anterior region. Since many appliances need to cover parts of the palatal region, such as obturators, hyrax appliances and TPA, accurate reproduction of the palatal area is of paramount importance.[10,11] This would help in saving time and make archiving of dental records more feasible as digital versions require less physical space and are easier to communicate for discussions and study purpose.

The aim of this study was to evaluate the accuracy of digital scans by comparing palatal vault depth measurements recorded on digital and plaster models in inter canine and inter molar region.

METHODOLOGY

This cross-sectional comparative study was conducted at the orthodontics department of Rehman College of Dentistry, Peshawar (RCD) from July 2020 to December 2020. The study sample was selected using non-probability consecutive sampling technique and of consisted of thirty pairs of good quality dental casts (30 plaster and 30 digital). Ethical approval was sought from the research committee of RCD (EC Ref No: 2021-04-064). The informed consent from the patients was taken at the time of obtaining diagnostic records. Pre-treatment digital and manual study models, with complete permanent dentition except third molars were used to record the measurements. Models with palatal defects/lesions and blocked out canines or grossly carious first molars were excluded from the study. Two examiners (KK and IK) working independently recorded palatal vault depth on plaster casts and on digital images of the same plaster casts, at the following regions:

Inter canine region: the perpendicular distance from the center of palatal vault to a line drawn along the cusp tips of permanent maxillary canines.

Inter molar region: the perpendicular distance from the center of palatal vault to a line drawn along the distal margins of permanent maxillary first molars (Figure 1).

Manual method: Intraoral impression with sodium alginate were taken and poured using conventional method with dental stone. The plaster models were assessed to ensure no voids or bubbles were present in the regions of interest which could affect measurements. A section of brass wire was stretched from the depth of palate to a ruler placed across the canines and first molars (figure 2). A digital Vernier caliper was used to obtain measurements from the brass wire to the nearest of 0.01mm accuracy (figure 3).

Digital method: Digital models were obtained by scanning the plaster models using Carestream Scan Flow (Carestream Dental LLC, Atlanta, USA) intra oral scanner with an average scanning time of 5 minutes for each arch. Scanned images of the plaster models were imported as STL files into CS Model plus software version 7.0. which allowed 3D manipulation of the virtual models. Measurements were taken to the nearest 0.01mm using the tool of distance measurement in the CS software (Figures 1 and 4). Each manual and digital measurement was repeated after two weeks of data collection by the same examiners (K.K and I.K) for intra and inter examiner reliability.

DATA ANALYSIS

Means and standard deviations were calculated for the continuous variables. Shapiro Wilk test was applied to check the normality of distribution of data. Paired t test was applied to compare the measurements of palatal vault depth, carried out on digital and plaster models.

Intra observer reliability was assessed with Pearson correlation coefficient with $r > 0.75$ indicating good reliability. Independent sample t test was used to evaluate gender differences between manual and digital measurements for both variables ($P < 0.05$ indicating significant differences)

RESULTS

30 pairs of dental casts of the maxillary arch (13 males and 17 females) were used to record the measurements. Means and SD of palatal depth measurements at inter canine and inter molar regions, recorded both manually and digitally, are given in the table 1. The two examiners independently recorded the manual and digital measurements on plaster and digital models respectively. Since the correlation between the two sets of measurements was good ($r > .75$) the measurements from one examiner were used to assess the differences. A statistically significant difference was found between manual and digital inter canine palatal depths ($P < 0.05$). Difference between manual and digital inter molar measurements was insignificant statistically ($P > 0.05$). The values are shown in table 2. Intra and

inter observer agreement for the measurements was reasonably good (r > .75) table 3. Gender differences for the primary variables were statistically insignificant.

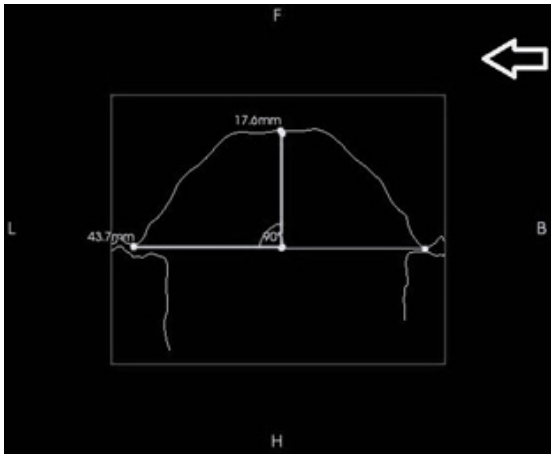

Fig 1: Digital method of measuring palatal vault depth (intermolar-distance shown).

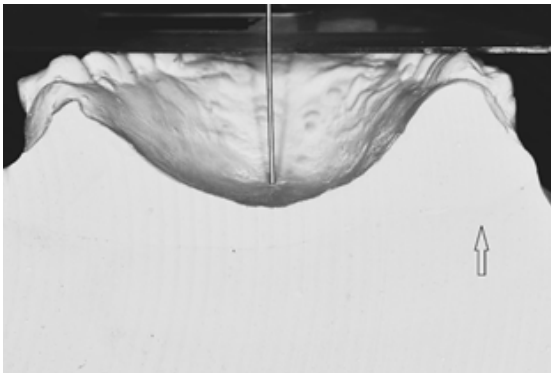

Fig 2: Manual method for recording palatal vault depth.

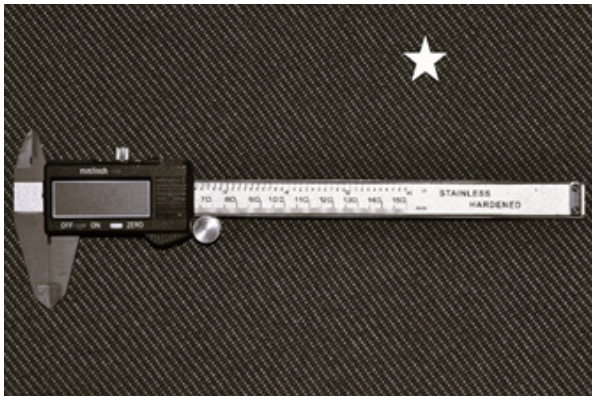

Fig 3: Digital caliper for manual measurements

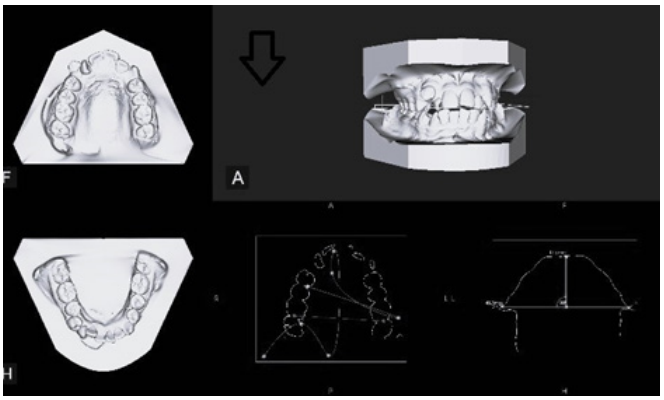

Fig 4: Digital models in Carestream imaging software.

TABLE 1: COMPARISON OF MEAN INTERCANINE AND INTERMOLAR WIDTHS WITH MANUAL AND DIGITAL METHODS. *SIGNIFICANT AT P < .05

Manual			Digital		Mean Difference	P
	Mean	SD	Mean	SD	0.694	.001*
Inter canine	6.99	1.34	6.29	1.97		
Inter molar	19.70	1.36	19.50	2.06	0.197	.074

TABLE 2: GENDER BASED COMPARISONS OF INTERMOLAR AND INTERCANINE WIDTHS

	Means				Mean Difference	P
	Male		Female			
Intercanine (Manual)	6.74	1.08	7.17	1.51	0.43	.396
Inter canine (Digital)	6.00	1.32	6.51	1.8	0.51	.318
Inter molar (Manual)	19.66	2.57	19.73	1.44	0.07	.927
Inter molar (Digital)	19.60	2.77	19.43	1.38	0.17	.833

TABLE 3: INTRAOBSERVER RELIABILITY COEFFICIENTS DIGITAL AND MANUAL MEASUREMENTS. *SIGNIFICANT AT P < .05

	Pearson correlation	P
Inter canine (Manual)	.852	.004*
Inter canine (Digital)	.929	.002*
Inter molar (Manual)	.966	.000*
Inter molar (Digital)	.993	.000*

DISCUSSION

Many studies have been conducted on digital models for recording various measurements using scanners from different manufacturers.[8,12,13] No previous studies have been found to record and compare palatal vault depth between manual and digital models. Palatal vault depth of the maxillary casts, at the inter canine and the inter molar area, was measured manually with digital caliper. The dental casts were scanned with Carestream 3600 intraoral scanner to obtain digital images and the measurements were repeated.

Plaster models are essential records in orthodontics and are considered gold standard for recording measurements such as palatal depth.[14] Measurements made on plaster models are easy to reproduce and can be accurately recorded using digital calipers. Therefore, we have used plaster models in this study for recording palatal depth at the two regions.

Measurements for palatal vault depth showed differences on plaster and digital casts. Mean difference for palatal depth at the inter canine region was statistically significant (p= .001) while it was statistically insignificant at the inter molar region (p= .074) for the two methods. Study by Sousa et al.[15] compared linear measurements taken with digital caliper on 20 plaster models and their digital scans captured with a surface laser scanner. Their results were in agreement with our study. They found statistically insignificant difference with either method. Similarly, the results of a study conducted by Bell et al.[16] support the present study. They compared measurements on dental casts and measurements from 3D images and found no statistically significant difference.

However, some studies are in contradiction to our results. Santoro et al.[4] comparatively assessed tooth size, overjet and overbite from plaster casts and scanned digital images of the same dental casts. While the differences for tooth size and overbite were significant statistically, overjet difference between the two methods was insignificant. The type of measurements recorded and the methods used to assess the aforementioned variables could be the possible reasons for difference in their results. Abizadeh et al.[17] also used plaster casts and their digital versions to record various measurements. They reported statistically significant differences between the two methods. Quimby et al.[18] reported statistically significant differences for all the measurements except for the mandibular inter canine distance recorded on computer-based models and plaster models.

We did not find any significant differences in palatal vault depth measurements regarding gender. Mankapure et al.[19] made direct measurements on dental casts with digital caliper. To assess palatal vault depth at the molar region, they compared 500 dental casts, equally distributed for gender. They could not find statistically significant difference between male and female patients for palatal depth.

In this study, palatal vault depth measured at the inter canine region showed statistically significant difference between the two methods. However, intermolar region palatal vault depth comparison yielded statistically insignificant differences. The difference in the morphology of palatal vault at the molar and canine area could be a possible explanation. At its depth, palate presents somewhat uniform and smooth surface at the molar region. While in the canine area, palatal vault has irregular surface owing to the presence of the rugae. This combined with the sloping palatal surface makes recording palatal depth manually difficult as compared to the digital mode.

The limitations of the present study were small sample size and the method used to record palatal vault depth manually. Future studies with greater sample size and more precise methods of measuring palatal depth manually like palatometer should be carried out. Also, digital models taken with various scanners and software tools should be compared for accuracy.

CONCLUSION

1. Palatal vault depth measured at the inter molar region on plaster models and digital models showed insignificant differences statistically.
2. At the inter canine area, palatal vault depth recorded on plaster models and digital models showed statistically significant difference, but the magnitude of the difference was small enough to be of any clinical significance.

3. In clinical settings, digital models might be used as a substitute to plaster models for recording palatal depth.

REFERENCES

1 Kumar AA, Phillip A, Kumar S, Rawat A, Priya S, Kumaran V. Digital model as an alternative to plaster model in assessment of space analysis. J. Pharm. Bioallied. Sci. 2015;7:S465–9.

2 Peluso MJ, Josell SD, Levine SW, Lorei BJ. Digital models: An introduction. Semin. Orthod. 2004;10:226–38.

3 B M, H R. The holodent system, a new technique for measurement and storage of dental casts. Am. J. Orthod. Dentofac. Orthop. 1992;102:113–9.

4 Müller P, Ender A, Joda T, Katsoulis J. Impact of digital intraoral scan strategies on the impression accuracy using the TRIOS Pod scanner. Quintessence Int. (Berl). 2016;47:343–9.

5 Ender A, Mehl A. Accuracy of complete-Arch dental impressions: A new method of measuring trueness and precision. J. Prosthet. Dent. 2013;109:121–8.

6 Treesh JC, Liacouras PC, Taft RM, Brooks DI, Raiciulescu S, Ellert DO, et al. Complete-arch accuracy of intraoral scanners. J. Prosthet. Dent. 2018;120:382–8.

7 Warnecki M, Nahajowski M, Papadopoulos MA, Kawala B, Lis J, Sarul M. Assessment of the reliability of measurements taken on digital orthodontic models obtained from scans of plaster models in laboratory scanners. A systematic review and meta-analysis. Eur. J. Orthod. 2022;44:522-9.

8 Naoumova J, Alfaro GE, Peck S. Space conditions, palatal vault height, and tooth size in patients with and without palatally displaced canines: A prospective cohort study. Angle Orthod. 2018;88:726–32.

9 Kattadiyil MT, Mursic Z, Alrumaih H, Goodacre CJ. Intraoral scanning of hard and soft tissues for partial removable dental prosthesis fabrication. J. Prosthet. Dent. 2014;112:444–8.

10 Londono J, Abreu A, Baker PS, Furness AR. Fabrication of a definitive obturator from a 3D cast with a chairside digital scanner for a patient with severe gag reflex: A clinical report. J. Prosthet. Dent. 2015;114:735–8.

11 Quaas S, Rudolph H, Luthardt RG. Direct mechanical data acquisition of dental impressions for the manufacturing of CAD/CAM restorations. J. Dent. 2007;35:903–8.

12 Gan N, Xiong Y, Jiao T. Accuracy of intraoral digital impressions for whole upper jaws, including full dentitions and palatal soft tissues. PLoS One 2016;11:e0158800.

13 Kusnoto B, Evans CA. Reliability of a 3D surface laser scanner for orthodontic applications. Am. J. Orthod. Dentofac. Orthop. 2002;122:342–8.

14 Lee JT, Cangialosi TJ. Comparison of Measurements made on Plaster and CBCT-Scanned Models. J. Oral Health Dent. Manag. 2014;13:1124-30.

15 Sousa MVS, Vasconcelos EC, Janson G, Garib D, Pinzan A. Accuracy and reproducibility of 3-dimensional digital model measurements. Am. J. Orthod. Dentofac. Orthop. 2012;142:269–73.

16 Bell A, Ayoub AF, Siebert P. Assessment of the accuracy of a three-dimensional imaging system for archiving dental study models. J. Orthod. 2003;30:219–23.

17 Abizadeh N, Moles DR, O'Neill J, Noar JH. Digital versus plaster study models: How accurate and reproducible are they? J. Orthod .2012;39:151–9.

18 Quimby ML, Vig KWL, Rashid RG, Firestone AR. The accuracy and reliability of measurements made on computer-based digital models. Angle Orthod. 2004;74:298–303.

19 Mankapure PK, Barpande SR, Bhavthankar JD. Evaluation of sexual dimorphism in arch depth and palatal depth in 500 young adults of Marathwada region, India. J. Forensic Dent. Sci. 2017;9:153–6.

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3 Jawad Ullah Shah:	Materials, data collection, results compilation, discussion.
4 Sohrab Shaheed:	Supervision, analysis, critical review.
5 Kanza Khan:	Materials, data collection.
6 Iqra Khan:	Materials, data collection.