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Original Article

Radiology Section

Comparative Study of MDCT with Plaster Cast Model of Dentoalveolar Arch Morphology

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ABSTRACT

Introduction: Dentoalveolar arch morphology and its measurements are of importance in various disciplines of dental science. It is usually studied by impression plaster cast models with mechanical calipers or scanned and digitized dental models. Multidetector Computed Tomography (MDCT) can be used to obtain similar data for the study of dentoalveolar arch morphology.

Aim: Present study was done to know the accuracy of distance measurements done by MDCT in comparison with plaster cast models. Also to determine the potential benefits and advantages of MDCT measurements over plaster cast measurements of dentoalveolar morphology.

Materials and Methods: Comparative study was carried out in 48 cases, who underwent MDCT scans of head and neck for various other causes. MDCT distance measurements of dentoalveolar arch by MDCT and plaster cast model was done. Pearson's correlation was applied for calculation the correlation. The p-value of less than 0.05 was considered statistically significant.

Results: Out of the 48 cases, age group ranged from 5 to 53 years. Proportion of males and females were 28 (58.3%) and 20 (41.7%) respectively. MDCT measurements showed a strong positive correlation with that of plaster cast measurements ($p<0.05$). There was no statistically significant difference in the mean values for distance measurements except for palatal arch distance ($p>0.05$)

Conclusion: MDCT is a useful and reliable imaging tool to evaluate normal morphology and abnormalities of the dental arch. There was no significant differences in measurements obtained by MDCT and plaster cast, making MDCT a useful method for digital acquisition, storage and communication, which also depicts the anatomy other than dental arch.

Keywords: Dental arch, Digital measurement, Palatal arch

INTRODUCTION

Plaster casts offer a gold standard method for measurement, documentation and to assess the progression of treatment for various dentoalveolar arch abnormalities [1]. Dentoalveolar measurements are useful in various disciplines of dental practice and are effective in studying the effects of mouth breathing on craniofacial morphology [2]. Imprint plaster cast provides precise and reliable information regarding dental arches, position of teeth and their dimensions. Orthodontic data's are obtained by measurements of dental casts by mechanical calipers and they are further stored for medico-legal purpose. Disadvantages of these cast models are breakage, storage, variations in measurements and sharing of information among other professional colleagues [3,4]. Photographs and other imaging technologies are also available for the study of dentoalveolar arch morphology. Photographic scanned digitized 3D dental models are used widely with almost same accuracy and precision as that of traditional plaster cast models [5]. Cone beam CT-scan is a very useful and non invasive imaging technique available for dental arch evaluation with low dose radiation compared to other CT modalities [6]. However, due to limited availability and cost of cone beam CT, routine MDCT scanners can be used for obtaining similar data regarding dentoalveolar morphologies. With availability of volume data and reconstruction techniques electronic caliper measurements can be done with great precision and accuracy. To the best of our knowledge there are no such studies documented in the literature regarding distance arch measurements of dental arch by MDCT.

MATERIALS AND METHODS

Study Design

A prospective study was undertaken in the Department of Radiology, JSS Medical College and Hospital, Mysuru, Karnataka, India over a period of six months from August 2015- February 2016.

Subjects

Total of 48 cases who underwent MDCT of head and PNS, satisfying inclusion criteria were included in the study. Out of 48 cases, 28 cases underwent MDCT of head and 20 cases MDCT of paranasal sinuses, for clinical management.

Inclusion Criteria

1. Cases who have not undergone any orthodontic treatment hitherto,
2. Subjects without any abnormal oral habits
3. Subjects with negative history for any respiratory disease.

Exclusion Criteria

Fractures or neoplastic pathologies or any other conditions that alters the normal dentoalveolar arch morphology were excluded.

Data Collection

Axial images were taken with Philips Ingenuity Core 128 slice MDCT scanner (Netherland). Patient was positioned supine with head first and axial sections were captured in helical format by fixing the tube current at 120 kVp and 117 mAs. High resolution images were obtained with scan parameters of collimation 64 x 0.625, Pitch of 0.39, FOV of 220 mm, filter at Y-sharp (YC), slice thickness of 1 mm, window centering at 200 and window width of 2000. Multiplanar reconstruction was done from axial images in a dedicated work station to obtain coronal and sagittal images without any loss of volume data. On board 3D reconstruction software was used to obtain the Virtual 3D picture (VRT-Volume rendered Technique Image) of dentoalveolar arch.

Electronic calipers were used to measure the length of Palatal Arch (PAL), Height of the Palatal Arch (PAH), Inter-Canine Distance (ICD), Inter-Premolar Distance (IPD), Inter-Molar Distances (IMD), Palatal Arch Length (PAL) and Palatal Arch Distance (PAD) [Table/Fig-1]. Measurements were taken between the most prominent buccal tooth surfaces. Palatal length was measured as a distance between the line connecting the 1st premolars and buccal surface of the medial incisors. PAD was measured by measuring the perpendicular distance between the above line and palatal arch at the midline. All the measurements were recorded by a single radiologist and hence no any inter-observer variability.

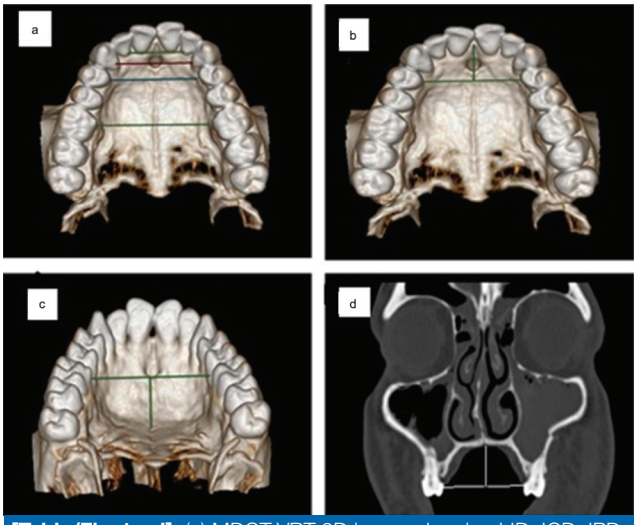
Plaster cast models of dentoalveolar arches of the same subjects, who underwent MDCT scans, were obtained. All plaster casts were made from patient's impressions by orthodontist. All of them were cast in plaster of Paris and were numbered with no personal data written on the casts. Plaster casts were completely reproduced with full arches with no surface damage or loss of tooth material or breakage. Similar measurements that were measured on MDCT volume rendered / MPR images were obtained from the plaster cast using mechanical calipers by a single orthodontist [Table/Fig-2,3].

Ethics

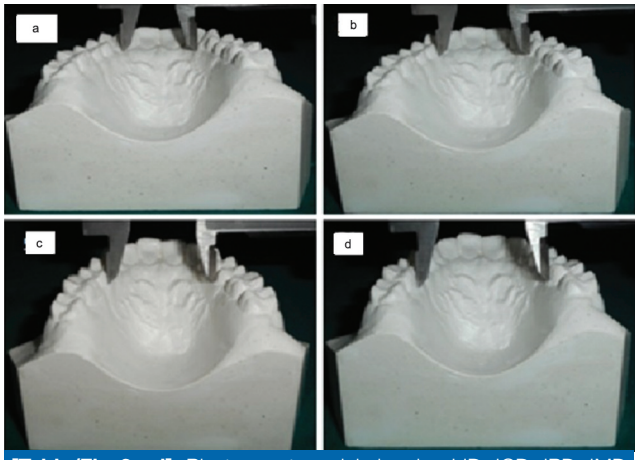
This study was approved by Institutional Ethical Committee and requisite patient consent was obtained. All cases included were the ones, who had already under gone CT-scan for various other complaints and hence question of unnecessary radiation was mitigated.The study was self funded with no financial implication for the patients.

STATISTICAL ANALYSIS

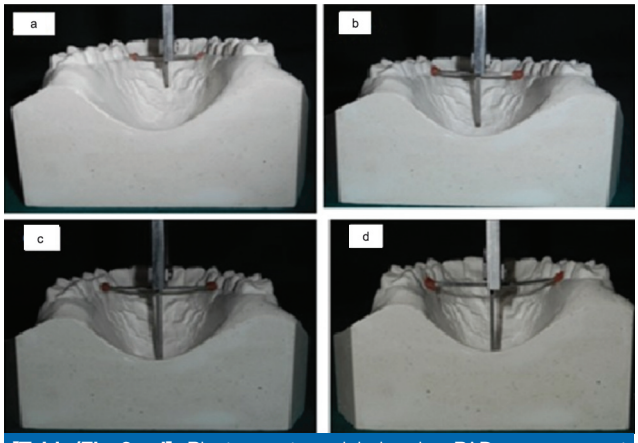
All the data was entered in Microsoft excel sheet for analysis. Categorical variables were reported as proportions.Analysis was done using Microsoft Excel 2013, SPSS 20.0. For 95% confidence interval values were calculated.



[Table/Fig-1a-d]: (a) MDCT-VRT 3D image showing LID, ICD, IPD, IMD measurement with electronic calipers; (b) MDCT-VRT 3D image showing PAL measurement; (c) MDCT-VRT 3D image showing PAD measurement; (d) Coronal CT image showing palatal arch measurement.
*Lateral Incisor Distance (LID); Intercanine Distance (ICD); Inter Premolar Distance (IPD); Inter Molar Distance (IMD); Palatal Arch Length (PAL); Palatal Arch Distance (PAD).



[Table/Fig-2a-d]: Plaster cast model showing LID, ICD, IPD, IMD measurement with mechanical calipers.
*Lateral Incisor Distance (LID); Intercanine Distance (ICD); Inter Premolar Distance (IPD); Inter Molar Distance (IMD).



[Table/Fig-3a-d]: Plaster cast model showing PAD measurement with mechanical calipers.
*Palatal Arch Distance (PAD).

Initially descriptive statistics like mean (standard deviation) and percentages were calculated. Reproducibility of the measurements on the plaster models and MDCT images were tested by paired't'-test and Pearson's correlation co-efficient for each measurement done.

RESULTS

Out of the 48 samples, the proportion of males and females were 28 (58.3%) and 20 (41.7%) respectively [Table/Fig-4]. Majority of the study subjects were in the age group of 11 to 20 years with 15 (53.6%) males and 8 (40.0%) females. The distance measurements on the plaster cast models and on the MDCT images are similar in nature and provide precise results. This was statistically confirmed by Pearson's correlation coefficients, paired sample statistics and p-values.

Age group (in years)	Sex		Total
	Male	Female	
<10	4 (14.3%)	5 (25.0%)	9 (18.8%)
11-20	15 (53.6%)	8 (40.0%)	23 (47.9%)
21-30	4 (14.3%)	4 (20.0%)	8 (16.7%)
31-40	5 (17.9%)	3 (15.0%)	8 (16.7%)
Total	28 (100.0%)	20 (100.0%)	48 (100.0%)

[Table/Fig-4]: Distribution of cases according to age and sex.

MDCT vs Plaster cast method	Pearsons correlation coefficient	p–value
Lateral Incisor Distance (LID)	0.964	<0.001
Intercanine Distance (ICD)	0.980	<0.001
Inter Premolar Distance (IPD)	0.984	<0.001
Inter Molar Distance (IMD)	0.995	<0.001
Palatal Arch Length (PAL)	0.986	<0.001
Palatal Arch Distance (PAD)	0.997	<0.001

[Table/Fig-5]: Pearson correlation co-efficient for assessment of dental arch measurements by plaster cast and MDCT methods.

	Measure-ments	Mean	df	T	p value
LID	Plaster cast	14.4771 ± 1.82818	47	-.206	.838
	MDCT	14.4917 ± 1.82673	47		
ICD	Plaster cast	21.6396 ± 2.06971	47	.206	.837
	MDCT	21.6271 ± 2.11959	47		
IPD	Plaster cast	26.1458 ± 2.53930	47	-1.209	.233
	MDCT	26.2250 ± 2.53071	47		
IMD	Plaster cast	33.0833 ± 3.57249	47	.327	.745
	MDCT	33.0667 ± 3.64326	47		
PAL	Plaster cast	19.9063 ± 3.38390	47	1.138	.261
	MDCT	19.8104 ± 3.44817	47		
PAD	Plaster cast	10.9292 ± 2.51463	47	2.469	.017
	MDCT	10.8500 ± 2.58835	47		

[Table/Fig-6]: Comparison of mean difference of dental arch measurements by plaster cast and MDCT measurements.

We observed that the dental arch measurements i.e, Lateral Incisor Distance (LID), ICD, IPD, PAD and PAL estimated by plaster cast and CT methods have statistically significant strong positive correlation co-efficient with all observed values above 0.9. Also there were no statistically significant differences in the mean values for the palatal arch measurements measured by plaster cast and CT method [Table/Fig-5], except for PAD [Table/Fig-6].

DISCUSSION

Present study proposes a novel method for obtaining digital data using MDCT images for dental arch measurements. Various advantages and disadvantages of plaster casts, 3D printed photocopies, digitally scanned models, and MDCT images are discussed in the present study. Photographic scanned and digitized 3D [7] dental models are widely used with greater precision as that of plaster models for dentoalveolar measurements [8-10].

Although, cone beam CT and conventional CT have been mentioned by numerous authors [11,12] here we present the attributes of MDCT in comparison with the traditional plaster casts. MDCT offers advantage of faster scanning times and are easy to store and share the images in digital format. New 3D models of the same can be obtained on demand which will eliminate the burden of storage problem [13]. There is also potential benefit of 3D printing of images using eco-friendly materials. MDCT do have certain limitations with requirement of trained technician, legalities of sharing patient's data and possible loss of the digital data due to technical errors. High cost and risk of radiation, although within acceptable limits, are the few limitations of MDCT. However, with increased availability of new generation CT scanners the cost and radiation doses have come down significantly. It completely negates the need for a qualified lab assistant required for

production of plaster casts and the unpleasant experience of giving out dental impression by the patient.

The necessary condition which needs to be met in order to use MDCT in dentistry is its accuracy and precision. Although, it is evident, plaster casts, 3D printed models and cone beam CT provides accurate measurements [14], we did not encounter any difference between them and MDCT for clinical purposes. Statistical analysis using standard tests confirmed the accuracy and precision of the measurements on the MDCT images. Keeping patient's data in digital form can further help to solve the storage problem. Digitalisation of the data also offers a solution for retrieval and transfer of the patient's data as and when required by the team among various physicians responsible for the care of patient. However, from the legal point of view one must be extremely careful while sharing patient's data as there are potential confidentiality and privacy issues that could be prone to misuse. It is imperative that MDCT could play an increasingly important role in many fields of dentistry. Further, research is required in this field and there is a need to develop technology on direct 3D printing from MDCT source data.

The results of this study also showed that digital models generated from MDCT imaging not only offer diagnostic information but also other information such as bone levels, root positions, and TMJ status. These informations are not possible on ortho CAD models. Hence, we conclude that MDCT can be used as a reliable method of obtaining and storing 3D digital data of dental arch.

CONCLUSION

It is possible to obtain precise measurements of dentoalveolar arch using MDCT images. Caliper measurements done on imprint plaster cast models and MDCT images are equivalent. MDCT surface rendered 3D images can replace the process of plaster cast making as it is easier, faster, non-invasive and provides excellent anatomical details.

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