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Correlation of various dental parameters of mandibular first molar with age, body weight and breed in healthy dogs

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Abstract

The aim of this study was to investigate the relationship of different radiographic parameters of mandibular first molar with respect to age, body weight and breed in healthy dogs. Overall, 50 dogs with the age from 5 to 156 months and body weight from 6.00 to 45.00 kg of various breeds were made the subject of study. Animals were categorized into different groups based on age, body weight and breed. A new dental parameters measurement technique was standardised which was in line with modified Lind's measurement technique of human dentistry. A significant decrease in least square count means of dental parameters was observed in age group 1 (0 - 12 months) in comparison with group 2 (13 - 60 months) and group 3 (> 60 months). A significant decrease in least square count means of dental parameters was observed in group A (0.00 - 10.00 kg) in comparison with group B (11.00 - 25.00 kg) and group C (> 25.00 kg). The root canal width showed a significant decrease with an increase in age; therefore, it was difficult to approach pulp cavity in older dogs. Small breeds showed decline in root length/crown height (R/C) ratio and mandible height/first mandibular molar height (MH/M1H) ratio in comparison with medium and large breeds because of which there were more chances of tooth loosening in smaller breeds. Regression equations formulated with respect to body weight and age can act as a ready reference to calculate values of different dental parameters at places where dental radiography is not available.

Introduction

Mandibular first molar (M1) was made the subject of this study because it was one of the strategic teeth most commonly subjected to grinding. Exploration of relationship between tooth dimensions, age and body size plays an important role in the forensic odontology and aesthetic dentistry.[1] Prognostic assessment of individual teeth is mandatory for oral rehabilitation procedures like prosthetic restoration, to predict dental longevity and selection of suitable prosthetic abutments. To achieve the success of dental prosthesis for M1, clinically most appropriate prosthetic abutments are recommended. Measurements of different radiographic parameters are helpful in endodontic treatments as well as prosthodontics. Clinical root length/crown height (R/C) ratio determined radiographically is of great significance in various prosthetic restorations e.g., overdenture, fixed dental prosthesis or removable partial denture and may act as a reference value for procedures like prosthodontics and orthodontics.[2] Mandible height/first mandibular molar height (MH/M1H) ratio plays a significant role in determining the susceptibility of tooth loosening and periodontitis.[3] The root canal width (RCW) measurement helps in understanding the change due to ageing and is helpful in endodontic therapies.[4] The aforementioned radiographic measurements of tooth were reported adequately in human dentistry; but, review of literature suggested a gap in radiographic assessment of tooth, especially strategic tooth like M1 in veterinary dentistry. To bridge this gap, this study was aimed to correlate different radiographic parameters of M1 with the body weight, age and breed of the dog.

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Materials and Methods

This study was conducted keeping all ethical and animal welfare issues under consideration and was approved by the Institutional Animal Ethics Committee, GADVASU vide proposal number of GADVASU/2020/ IAEC/55/12, registered by CPCSEA, under registration number of 497/GO/Re/SL/02/CPCSEA.

The present study was conducted at Multi-speciality Veterinary Hospital, Department of Veterinary Surgery and Radiology, Guru Angad Dev University of Veterinary and Animal Sciences, Ludhiana, India. The dogs included in this study (n = 50) were having healthy dentition with normal number of teeth. Radiographs were obtained under general anesthesia (given for some other unrelated elective surgeries) using portable digital x-ray machine (iM3 – PORT-X II, CenQuip Pty Ltd., Sydney, Australia) and computer radiography system using occlusal dental films (2.00 × 3.00 cm, 2.00 × 4.00 cm, 3.00 × 4.00 cm, 2.70 × 5.40 cm, 5.70 × 7.50 cm and 5.70 × 9.40 cm). The clinical cases were divided into groups as per age, body weight and breeds as follows: Based on age: 1: 0 - 12 months, 2: 13 - 60 months and 3: > 60 months. Based on body weight: A: 0.00 - 10.00 kg, B: 11.00 - 25.00 kg and C: > 25.00 kg. Based on breeds: small, medium and large breeds.

In human dentistry, teeth were measured by modified Lind's measurements to measure R/C ratio or clinical R/C ratio of M1.[2] Due to the gap in review of literature, a novel dental radiography measurement technique in line with modified Lind's measurements technique was used in this study. The root length (RL) and crown height (Crh) of M1 were expressed by three lines (Fig. 1). Line 'm' was defined as the line connecting the mesial and distal alveolar bones of M1. Line 'i' was drawn from the highest point of incisal tip or buccal cusp parallel to the line 'm'. Similarly, line 'a' was drawn from the tip of mesial buccal root apex (the longest buccal root) parallel to the line 'm'. The Crh was defined as the perpendicular line from 'i' to 'm' and the RL was defined as the perpendicular line from 'm' to 'a'. Subsequently, R/C ratio was obtained by dividing RL with Crh.

Mandible height was measured as a perpendicular distance from the furcation point up to the line 'j' along the mandibular ventral cortex of M1 (Fig. 2). First mandibular molar height was calculated by adding Crh and RL of M1. The MH/M1H ratio was obtained by dividing MH with M1H.

The contact point of proximal and middle one third of the distal RL was taken as a reference point for measuring root width (RW) and root canal width (RCW; Fig. 3). Root width was denoted by the line 'ab' from mesial to distal surface of distal root of M1; whereas, RCW was denoted by the line 'cd' from mesial to distal surface of distal root canal of M1. Root width/root canal width ratio was obtained by dividing RW with RCW.

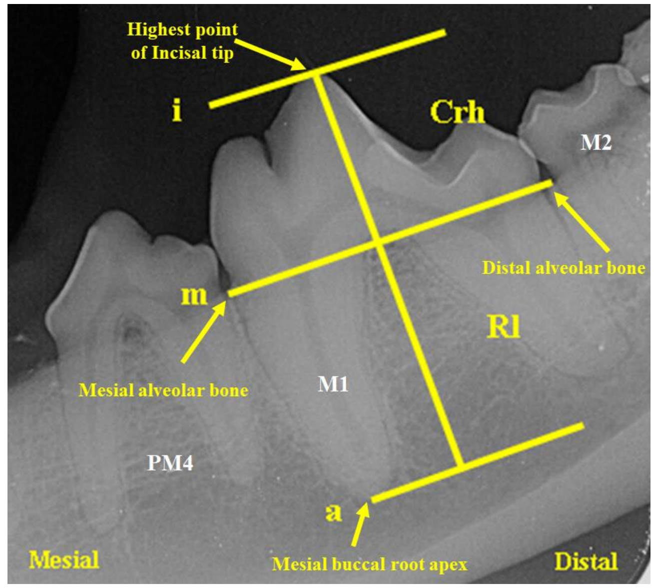

Fig. 1. Intra-oral radiograph showing the guideline for measurements of the root length/crown height ratio in mandibular first molar (M1), where Crh is crown height, M2 is mandibular second molar, PM4 is mandibular fourth premolar and Rl is root length in dogs. Line "m" is connecting the mesial and distal proximal alveolar bone. An incisal/occlusal reference line (i) was drawn from the highest point of incisal tip or buccal cusp in the form of a tangent perpendicular to the longitudinal line "m".

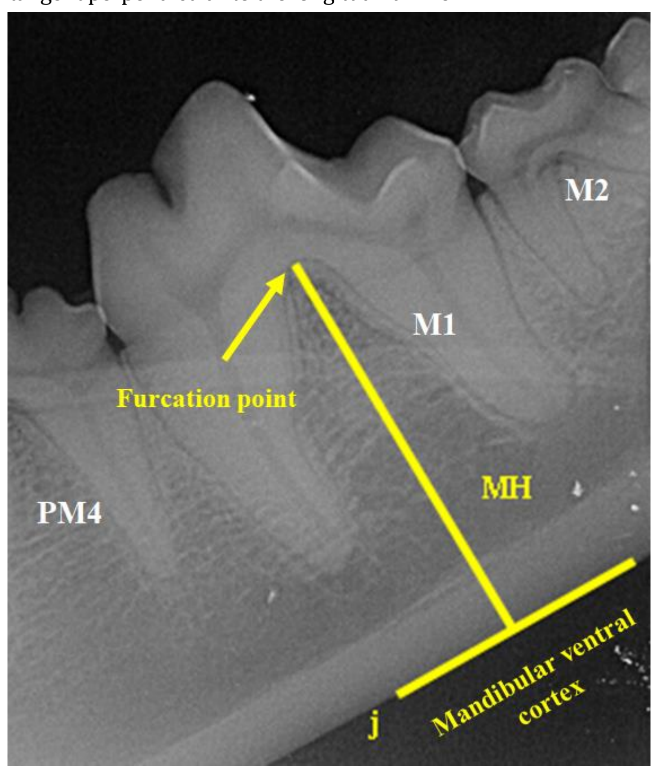

Fig. 2. Intra-oral radiograph showing the guideline for measurements of mandible height (MH) at mandibular first molar (M1), where M2 is mandibular second molar and PM4 is mandibular fourth premolar in dogs. Line 'j' is the line along the mandibular ventral cortex.

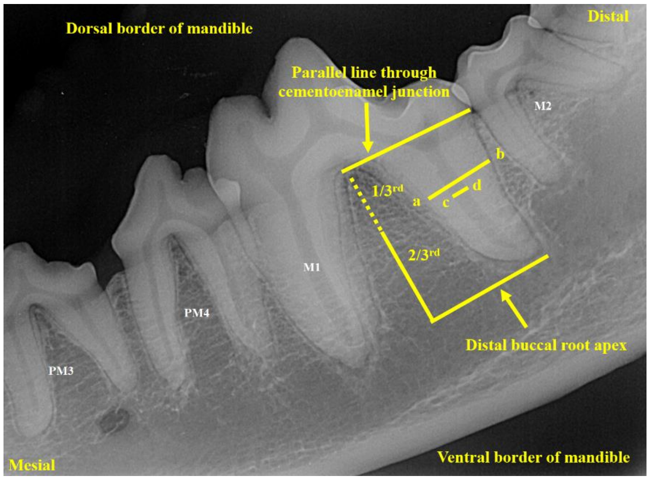

Fig. 3. Intra-oral radiograph showing guideline for measurements of root width and root canal width of mandibular first molar (M1), denoted by 'ab' and 'cd' lines, respectively; where M2 is mandibular second molar, PM3 is mandibular third premolar and PM4 is mandibular fourth premolar in dogs. Dotted line shows 1/3rd of the distance between the cementoenamel junction and the root apex served as a reference point for measuring root width (RW) and root canal width (RCW) of the distal root.

Statistical analysis. Statistical analysis of the parameters recorded was performed to see the effect of age, weight and breed groups. Simultaneously, Multiway ANOVA and Tukey method were used for *post hoc* test to compare the least square means for different levels of each and every factor. The least square means were used to adjust the effect of other factors. The analysis was performed by SPSS Software (version 20.0; IBM Corp., Armonk, USA) using GLM and calculation of correlation coefficient and regression equation was performed using GraphPad Prism (version 8.4.3; GraphPad Software Inc., San Diego, USA). Statistical analysis was performed to determine possible associations between different measurements with body weight, age and breed. A p values less than 0.05 were considered statistically significant.

Results

Evaluation of dental radiographic parameters in different age groups. Mean ± standard error of the mean (SE) of age of dogs presented was 65.22 ± 5.54 months, ranging from 05 to 156 months. The highest number of dogs was in the group 3 (50.00%; n = 25) followed by group 2 (32.00%; n = 16) and group 1 (18.00%; n = 09), respectively. A significant decrease in the least square means of RL and MH was observed in group 1 with respect to the least square mean values of groups 2 ($p = 0.001$) and 3 ($p = 0.001$). Group 1 also showed a significant decrease in the least square mean values of M1H with respect to values of groups 2 ($p = 0.006$) and 3 ($p = 0.001$). Similar trend was also observed in MH/M1H ratio, where a significant decrease in the least square mean values of group 1 was observed with respect to the values of groups 2 ($p = 0.004$) and 3 ($p = 0.008$). Parallel to the above parameters, group 1 showed a significant decrease in RW compared to the values of groups 2 ($p = 0.041$) and 3 ($p = 0.020$). Although a non-significant ($p > 0.05$) decrease in the least square mean values of Crh and R/C ratio was observed in group 1 with respect to the groups 2 and 3. The RCW showed a significant increase in group 1 compared to the groups 2 ($p = 0.038$) and 3 ($p = 0.043$). Group 1 showed a significant decrease in RW/RCW compared to the values of groups 2 ($p = 0.039$) and 3 ($p = 0.026$), (Table 1).

Evaluation of dental radiographic parameters across different weight groups. Mean ± SE value of body weight of dogs presented was 23.00 ± 1.72 kg, ranging from 6 to 45 kg. The highest number of dogs was presented in group B (44.00%; n = 22) followed by group C (38.00%; n = 19) and group A (18.00%; n = 09), respectively. A significant decrease in Crh was observed in the least square mean values of group A with respect to groups B ($p = 0.056$) and C ($p = 0.001$). Similarly, a significant decrease in the least square mean values of MH/M1H ratio was observed in group A with respect to values of groups B ($p = 0.001$) and C ($p = 0.001$). A Significant decrease was observed in the least square mean values of RW in group A against groups B ($p = 0.012$) and C ($p = 0.001$). A significant increase in R/C ratio was observed in group C with respect to the least square mean values of groups A ($p = 0.003$) and B ($p = 0.012$), (Table 1).

Evaluation of dental radiographic parameters based on dogs' breed. Clinical cases presented were grouped as large (42.00%; n = 21), medium (30.00%; n = 15) and small (28.00%; n = 14) breeds, respectively. A significant decrease in the least square mean values of Crh, Rl, R/C ratio, MH, M1H, MH/M1H ratio and RW was observed in the small breed group with respect to values of medium ($p = 0.001$) and large ($p = 0.001$) breed groups, (Table 1).

Correlation and linear regression analysis of age with dental radiographic measurements in dogs. A significant, positive and moderate correlation was observed between age groups concerning Rl, MH, M1H, MH/M1H ratio, RW and RW/RCW ($p < 0.05$). A significant, positive and weak correlation was observed between age and R/C ratio ($p < 0.05$). A significant and negative correlation was observed between RCW and age ($p < 0.05$). The regression equations obtained under this study show that the variables like Rl, R/C ratio, MH, M1H, MH/M1H ratio and RW significantly affected by age group of the animals ($p < 0.05$). Parameters like MH and M1H were highly dependent on age group of the animals; whereas, MH/M1H ratio was least dependent compared to the other dental radiographic parameters. By putting the age of animals at the place X in the regression equation, values of different parameters showing significant correlation could be obtained which can be useful in areas where dental radiograph is not available (Table 2).

Table 1. Different dental radiographic parameters (mm) across different age (months), weight (kg) and dog breed groups.

Groups	Crh	Rl	R/C ratio	MH	M1H	MH/M1H ratio	RW	RCW	RW/ RCW ratio
1 (0 - 12 months)	10.56 ± 0.84	12.33 ± 1.19^{b}	1.18 ± 0.06	18.11 ± 2.17^{b}	23.12 ± 1.89^{b}	0.77 ± 0.04^{b}	7.22 ± 0.68^{b}	2.33 ± 0.71^{a}	7.95 ± 2.19^{b}
2 (13 - 60 months)	12.00 ± 0.52	15.44 ± 0.84^{a}	1.28 ± 0.04	24.69 ± 1.66^{a}	27.34 ± 1.26^{a}	0.89 ± 0.03^{a}	8.81 ± 0.49^{a}	1.31 ± 0.27^{b}	9.60 ± 0.83^{a}
3 (> 60 months)	12.08 ± 0.30	15.72 ± 0.71^{a}	1.30 ± 0.04	24.68 ± 1.28^{a}	27.91 ± 1.02^{a}	0.87 ± 0.02^{a}	8.88 ± 0.43^{a}	1.28 ± 0.27^{b}	10.36 ± 0.92^{a}
A (0.00 - 10.00 kg)	10.11 ± 0.79^{b}	11.67 ± 1.08^{c}	1.16 ± 0.05^{b}	16.33 ± 1.67^{c}	22.06 ± 1.76^{c}	0.73 ± 0.02^{b}	6.56 ± 0.58^{b}	1.78 ± 0.66	9.00 ± 2.14
B (11.00 - 25.00 kg)	11.68 ± 0.44^{a}	14.45 ± 0.84^{b}	1.23 ± 0.04^{b}	22.91 ± 1.55^{b}	26.11 ± 1.20^{b}	0.86 ± 0.03^{a}	8.36 ± 0.44^{a}	1.64 ± 0.34	9.12 ± 0.99
C (> 25.00 kg)	12.68 ± 0.38^{a}	17.26 ± 0.33^{a}	1.37 ± 0.04^{a}	27.58 ± 0.77^{a}	30.02 ± 0.59^{a}	0.92 ± 0.02^{a}	9.74 ± 0.37^{a}	1.16 ± 0.22	10.65 ± 0.85
Small breed	9.57 ± 0.48^{b}	10.21 ± 0.73^{b}	1.07 ± 0.03^{b}	14.50 ± 1.05^{b}	20.01 ± 1.13^{b}	0.72 ± 0.01^{b}	6.14 ± 0.43^{b}	0.86 ± 0.27	10.38 ± 1.11
Medium breed	12.43 ± 0.43^{a}	16.27 ± 0.40^{a}	1.32 ± 0.05^{a}	26.40 ± 0.98^{a}	28.65 ± 0.61^{a}	0.92 ± 0.03^{a}	9.33 ± 0.35^{a}	1.73 ± 0.36	9.39 ± 1.13
Large breed	12.60 ± 0.43^{a}	17.33 ± 0.38^{a}	1.37 ± 0.03^{a}	27.43 ± 0.86^{a}	29.57 ± 0.60^{b}	0.91 ± 0.02^{a}	9.62 ± 0.34^{a}	1.71 ± 0.37	9.42 ± 1.15

Crh: Crown height; RI: Root length; R/C: Root length /crown height; MH: Mandible height; M1H: First mandibular molar height; MH/M1H: Mandible height/first mandibular molar height; RW: Root width; RCW: Root canal width; RW/RCW: Root width/ root canal width.

^{abc}Values with different superscripts within a column differ significantly ($p \le 0.05$).

Table 2. Correlation and linear regression analysis of age (months) and body weight (kg) with different dental radiographic measurements (mm) in dogs.

Parameters	Statistical analysis	Crh	Rl	R/C ratio	MH	M1H	MH/M1H ratio	RW	RCW	RW/ RCW ratio
Age	**Correlation coefficient**	0.25	0.34	0.29	0.34	0.32	0.3	0.35	-0.19	0.24
	Coefficient of determination	0.06	0.12	0.08	0.11	0.1	0.09	0.13	0.034	0.06
	Regression equation	Y = 0.01300 × X + 10.93	Y = 0.03079 × X + 13.08	Y = 0.001407 ×X + 1.181	Y = 0.05842 × X + 19.71	Y = 0.04379 × X + 24.01	Y = 0.0009324 × X + 0.7990	Y = 0.01905 × X + 7.322	Y = -0.006980 × X + 1.887	Y = 0.02786 × X + 7.863
	***p*-value**	0.09	0.016*	0.0421*	0.0168*	0.0242*	0.0344*	0.0118*	0.0198*	0.0136*
Weight	**Correlation coefficient**	0.53	0.66	0.48	0.67	0.64	0.568	0.54	-0.11	0.14
	Coefficient of determination	0.29	0.43	0.23	0.45	0.41	0.322	0.29	0.013	0.02
	Regression equation	Y = 0.09137 × Z + 9.678	Y = 0.1923 × Z + 10.66	Y = 0.007587 × Z + 1.098	Y = 0.3751 × Z + 14.89	Y = 0.2837 × Z+ 20.34	Y = 0.005694 × Z + 0.7288	Y = 0.09390 × Z+ 6.404	Y = -0.01360 × Z + 1.745	Y = 0.05193 × Z + 8.485
	Correlation coefficient	< 0.0001**	< 0.0001**	0.0004**	< 0.0001**	< 0.0001**	< 0.0001**	< 0.0001**	0.44	0.35

Crh: Crown height; RI: Root length; R/C: Root length /crown height; MH: Mandible height; M1H: First mandibular molar height; MH/M1H: Mandible height/first mandibular molar height; RW: Root width; RCW: Root canal width; RW/RCW: Root width/ root canal width; X: Age of dog; Y: Expected value of the dental radiographic measurements; and Z: Body weight of dog.

* and ** denote significance at 5.00% and 1.00% levels of significance, respectively.

Correlation and linear regression analysis of body weight with dental radiographic measurements in dogs. A significant, positive and strong correlation was observed among body weights with respect to Crh, Rl, MH, M1H, MH/M1H ratio and RW ($p < 0.01$). A significant, positive and moderate correlation was observed between body weight and R/C ratio ($p < 0.01$). However, a non-significant and negative correlation was observed between RCW and body weight ($p > 0.05$). The regression equation obtained under this study could help to predict the normal values of dependent variables like Crh, Rl, R/C ratio, MH, M1H, MH/M1H ratio and RW from body weight in dogs. The variables like MH, M1H and Rl were highly dependent on body weight of the animals; whereas, R/C and MH/M1H ratios were least dependent on body weight of the animals compared to the other dental radiographic parameters. By putting the body weight of animals at the place Z in the regression equation, values of different parameters showing significant correlation could be obtained which can be useful in areas where dental radiograph is not available (Table 2).

Discussion

The R/C ratio could be classified to either clinical R/C ratio or anatomical R/C ratio. The former R/C ratio took alveolar bone level as a reference point; whereas, the latter took cemento-enamel junction as a reference point.[5] Since the former R/C ratio provided better information regarding alveolar support, hence, in human dentistry the term "R/C ratio" implied clinical R/C ratio. This clinical R/C ratio was determined radiographically which was in line with the suggested R/C ratio measurement technique in this study.

In the proposed study, a significant increase in dental parameters except RCW was observed with advancement of age. Similar observations in human had been reported.[1] Significant proportionate changes in MH, M1H and MH/M1H ratio with advancement of age in dogs and human have been reported; which was in concomitant to this study.[3,6] Changes observed in RW, RCW and RW/RCW ratio with advancing age were similar to previous findings.[4,7] The RW/RCW ratio increases with increase in age of the animals.[8]

In the study described here, a significant increase in dental parameters except RCW was observed with increase in body weight. A significant increase in the Crh, Rl and R/C ratio with respect to body weight has been reported in human dentistry.[9] Proportionate increase in MH, M1H and MH/M1H ratio with respect to body weight in dogs had also been reported.[3]

A significant decrease in R/C and MH/M1H ratios was observed in small breeds in comparison with medium and large breeds. Likewise, small breeds are reported to have the problem of tooth loosening and periodontal affections and lower MH/M1H might be a significant factor for that.[10] A proportionally larger molar height relative to MH in small breeds might be the reason for increased incidence of periodontitis and subsequent tooth loss in these breeds in comparison with medium and large breeds. According to the data obtained in this study, RCW decreases with an increase in the age of dogs; therefore, it is difficult to approach pulp cavity during root canal therapy in older dogs in comparison with young ones.

A significant and positive correlation of dental parameters was observed with body weight and age. The RCW showed negative correlation with the age and body weight. In this study, small breed showed significantly lower R/C and MH/M1H ratios in comparison with other breeds. Regression equations obtained in this study are useful to predict the value of dental radiographic parameters showing significant correlation.

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Conflict of interest

The authors declare that there are no conflicts of interest.

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