Coronal Pulp Dimensions in Noncarious and Restored Deciduous Second Molars: A Radiovisiographic Study

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ABSTRACT

Purpose: The purpose of this study was to measure the coronal pulp dimensions in primary maxillary and mandibular second molars and to evaluate the influence on restorative procedures on them.
Methods: Included in this study were 80 4-7 year-old male and female patients with occlusal or proximal restorations on primary maxillary or mandibular second molars and with noncarious antimeres. Radiovisiographic images were captured utilizing standard bitewing radiographs via the parallel cone technique. Morphometric analysis was performed using Dexis and AutoCAD 2000 software, and data was analyzed using student's t test (unpaired).
Results: A significant difference was found in crown and coronal pulp dimensions in non-carious (sound) primary maxillary and mandibular second molars, even though no significant reductions were found in restored primary second molars.
Conclusions: Crown and coronal pulp dimensions were significantly greater in non-carious primary mandibular second molars than in maxillary second molars. The mesio-distal crown width of maxillary molars was greater in males than in females. Nonsignificant reductions were observed in amalgam restored primary maxillary and mandibular second molars over a period of six months. No significant difference in pulpal dimensions was observed when Class I restorations were compared with Class II restorations in either arch.
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The thickness of dental mineralized tissues surrounding the pulp varies from person to person, in relation to the size, shape, and type of tooth where it is encompassed. During cavity preparation on the tooth's mesial or distal sections, there is a risk of damaging the pulp horns. To avoid inflicting any harm to the pulp, the pulp horns are used as a guide to determine the thickness of the calcified tissue to be prepared.[1]

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Hence, it is important for the clinician to know and understand the hierarchy of cavity preparation and restoration variables in relation to pulpal injury and tertiary dentin formation. These factors not only predict the pulpal response after restoration, but also change pulpal dimensions. Numerous studies have been done to measure pulpal dimensions in permanent teeth.[2-14] Studies conducted to measure crown and pulpal dimensions in primary teeth, however, are sparse. Most studies have been conducted on the primary dentition, either utilizing bitewing radiographs or dental casts for the measurement of teeth dimensions.[4,8,15-18] Although conventional bitewing radiographs offer a reliable method of recording images intraorally, they risk exposing patients to considerable amounts of radiation. Due to a greater radiosensitivity known in children,[19] the next

best and latest alternative is radiovisiography (RVG), a digital imaging system.

The purpose of this study was to measure the coronal pulp dimensions in noncarious and restored primary second molars and to evaluate the influence of restorative procedures on the pulp chamber's dimensions with the help of Radiovisiography.

METHODS

This study was done 5 yrs back (April 2005). Patients were selected from past clinical work records of the Department of Pedodontic and Preventive Dentistry, Bapuji Dental College and Hospital, Davangere, Karnataka, India. All the amalgam restorations were done six months prior to radiographic procedure by single post graduate student of same Department. A total of 80 male and female patients were selected for the study. All patients having following criteria were included in study:

1. Patient were between 4 to 7-years-old;
2. All the patients had amalgam restoration done for their initial occlusal (lesion as a fine gray shadow just under the dentoenamel junction)[20] or proximal (lesion penetrating not more than half the enamel's thickness)[20] caries on second primary mandibular or maxillary molars by a single dentist under rubber dam.
3. Radiographic procedure (capturing of RVG images) was carried out 6 months after the placement of amalgam restorations.
4. Patients were cooperative and not physically or mentally handicapped.

All the patients were recalled for check up after six months of placement of amalgam restorations. They were examined for intact restorations and caries free (sound) contralateral counterpart (second primary molar). Further, they were divided equally into categories as experimental (restored primary second molars)/ Control group (caries free contralateral primary second molars), male/ female, maxillary/mandibular and occlusal/proximal restorations. A total of 80 such patients were randomly selected for study (See flow chart).

After a thorough clinical examination, an informed written consent was obtained from each patient's parent(s)/legal guardians(s) authorizing the radiographic procedure. Permission was also obtained from the Institutional Ethical Clearance Committee of Bapuji Dental College and Hospital located in Davangere (Karnataka) India, for same.

RADIOGRAPHIC PROCEDURE

Each subject was positioned comfortably on the dental chair in the Department of Pedodontics & Preventive Dentistry, Bapuji Dental College and Hospital, Davangere, Karnataka, India. A Dexis CCD sensor (Provision Dental system, Indonesia) was placed inside disposable polythene sleeves and positioned in the mouth with the help of a special holder that included a bite block and aiming ring. Bitewing RVG images were captured using the parallel cone technique .[21]

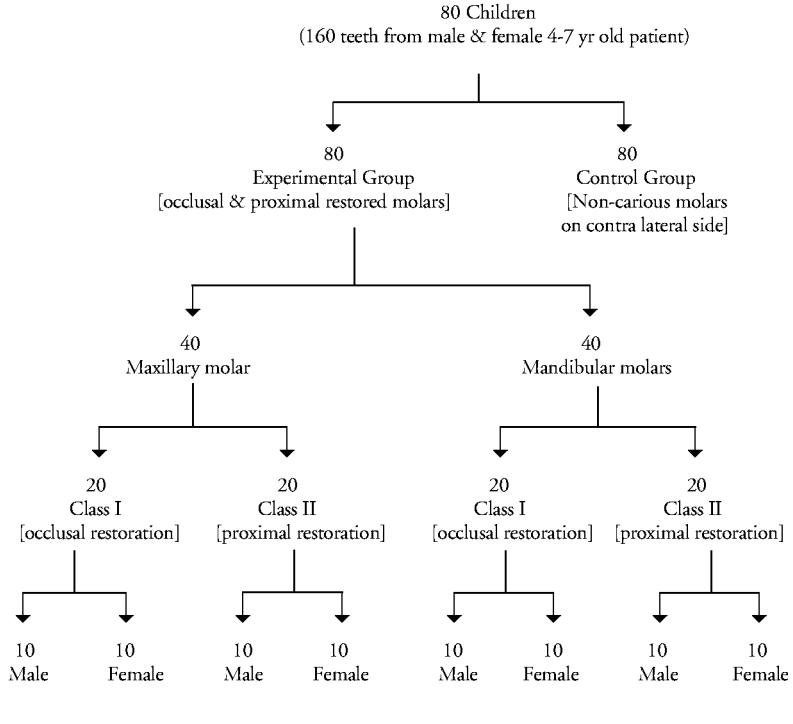
Dexis software (Dexis Digital Imaging system, Indonesia) was initialized, and the X-rays were taken. The radiographic images were displayed instantly on the computer monitor. Morphometric analysis was carried out for both restored (experimental) and noncarious (control) teeth utilizing Dexis (liner measurements) and AutoCAD 2000 software (area measurements) (Standard Disk Drives, Japan) by a single individual to avoid bias.

Because digitalized software was used, the chance of measurement error was negligible, so all measurements were done by single examiner (not blinded for study). Three measurements, however, were taken. Most often, the same measurements were found, but if any negligible difference was found, an average of the 3 values was taken by same examiner.

The following measurements were taken:

1. Coronal pulp size:

Flow chart illustrating division of control and experimental group patients according to arch, sex and type of restoration for study



a. mesiodistal crown width (mm); Fig 1
b. crown height (mm); Fig 1
c. crown width at the cervix (mm); Fig 1
d. crown area (mm^2); Fig 1
e. height of mesial pulp horn (mm); Fig 2
f. height of distal pulp horn (mm); Fig 2
g. pulp area of clinical crown (mm^2); Fig 2
h. total coronal pulp area (mm^2); Fig 2
i. pulp width at cervix (mm); Fig 2

2. effect of restoration on coronal pulp size:
   a. pulp area (ie, pulp area of clinical crown and total coronal pulp area [mm^2]); and
   b. pulp horn height (ie, mesial and distal pulp horns [mm]).

STATISTICAL ANALYSIS

Descriptive statistics, including means and standard deviations were calculated for each subgroup's parameters. The student's *t* test was used for comparing the mean levels of 2 groups. Statistical significance was predetermined at the probability level of 0.05 or less.

Formulae used for analysis:

$$\text{Mean, } x = \frac{\Sigma x_i}{n} \qquad xi = 1, 2, \ldots\ldots n$$

n = total number of cases evaluated

$$\text{Std. Deviation, SD} = \frac{\Sigma (x_i - x)^2}{n - 1}$$

$$\text{Variance} = SD^2$$

$$\text{Std. Error, SE} = SD / \sqrt{n}$$

$$\text{Student's t-test, (Unpaired)} \quad t = \frac{\text{Difference in means}}{\text{Std. Error of difference}}$$

$$\left(\frac{x1 - x1}{\text{Combined SD} \times \sqrt{\frac{1}{n1} + \frac{1}{n2}}} \right)$$

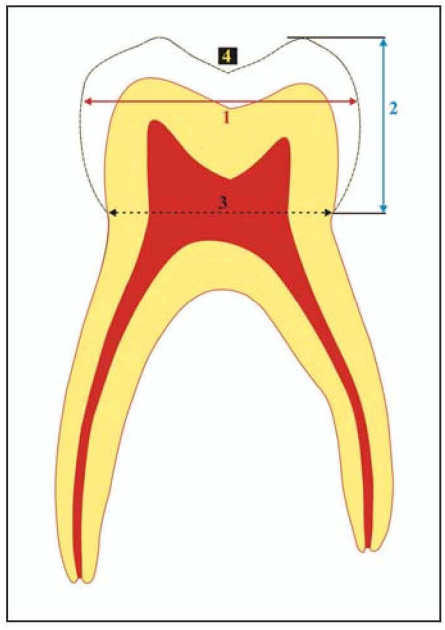


Figure 1. 1, Mesio-distal crown width; 2, Crown height; 3, Crown width at cervix; 4, Crown area 209 x 297 mm.

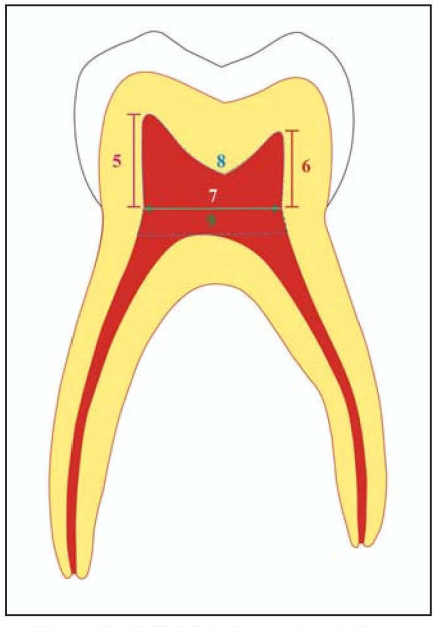


Figure 2. 5, Height of mesial pulp horn; 6, Height of distal pulp horn; 7, pulp area of clinical crown; 8,total coronal pulp area; 9, pulp width at the cervix 209 x 297 mm.

RESULTS

This study's results represent measurements from 80 restored and 80 noncarious contralateral primary second molars (total=160 teeth). On comparison of noncarious (sound) primary second maxillary and mandibular molars a significant difference was found among crown and coronal pulp dimensions (Table 1). Dimensions like mesiodistal crown width, crown height, pulp and crown width at the cervix, distal pulp horn height ($P<.001$), mesial pulp horn height ($P<0.05$) and total pulp area (mm^2)($P<0.01$) was greater in non-carious (sound) primary second mandibular molars than non-carious primary second maxillary molars. However, in same group no significant difference were observed when crown area was compared ($P=.17$).

When comparing coronal pulp dimensions in noncarious primary maxillary second molars in male and female subjects (Table 2), the *P*-value for mesiodistal crown widths in males was statistically significant ($P<.05$). However, all other eight dimensions on comparison were not significant. On the other hand, on comparison of pulp dimensions in non carious second mandibular molars in male and female subjects (Table 3), no statistically significant *P*-value was shown for any of 9 dimensions, in 4-7 yrs age group.

Variable degrees of reduction in pulp dimensions were found as a result of restorations when noncarious primary second molars were compared to its counterpart restored molars (Table 4). These differences in pulp area of clinical crown ($P=.44$), total coronal pulp area ($P=.66$), height of mesial pulp horn ($P=.09$), and distal pulp horn height ($P=.41$), however, were not statistically significant.

Comparing coronal pulp dimensions between Class I and II restorations on primary maxillary second molars (Table 5) and primary second mandibular molars (Table 6) revealed no statistically significant *P*-value for height of mesial pulp horn, distal pulp horn height, pulp area of clinical crown, and total coronal pulp area.

Table 1. Comparison of Coronal Pulp Dimensions in Non-carious Primary Maxillary Second and Mandibular Molars

Measurements	Maxillary (N=40) Mean±(SD)	Mandibular (N=40) Mean±(SD)	*P*-value
Mesiodistal crown width (mm)	9.66±0.78	10.48±0.76	<.001
Crown height (mm)	6.12±0.60	5.46±0.62	<.001
Pulp width at cervix (mm)	3.02±0.51	4.08±0.51	<.001
Crown width at cervix (mm)	7.26±0.62	8.03±0.83	<.001
Mesial pulp horn height (mm)	2.49±0.32	2.69±0.32	<.01
Distal pulp horn height (mm)	2.01±0.30	2.25±0.27	<.001
Pulp area of clinical crown (mm^2)	4.92±1.66	6.29±2.86	>.01
Total coronal pulp area (mm^2)	8.10±3.42	12.21±7.52	<.01
Crown area (mm2)	49.85±11.87	54.12±15.34	>.17

DISCUSSION

Preserving healthy pulp during operative procedures and its successful therapeutic management in the case of diseases are two of the most important challenges dentists face. The thickness of mineralized tissues surrounding the pulp varies depending on race, size, and tooth type. Having a detailed knowledge of pulp dimensions and common morphological variations is important in extensive restorative treatment to prevent accidental exposure.[5,13]

Certain factors injure the pulp, including dental caries, attrition, abrasion, erosion, trauma, and restorative procedures.[22] Pulp responds to all injurious agents by depositing secondary dentin, which is the main repair response of pulp. This dentin is secreted by odontoblasts and deposited along the entire tissue and may alter pulp dimensions.[23]

The daily rate of reparative dentin formation after operative procedures varies with time. In humans, the average daily reparative dentin formation has been reported to be 2.8 μm for primary and 1.5 μm for permanent teeth. The quantity of reparative dentin formed after operative procedures depends upon the cavity's depth.[6] Studies have revealed that reparative dentin is thicker after 8 weeks than 5 weeks, and it is also proportional to the amount of remaining dentin thickness.[10]

Radiographs are one of the best tools to measure pulp dimensions. Various studies have been conducted to measure coronal and radicular pulp cavity dimensions utilizing conventional radiographic techniques.[10-14] RVG utilizes intraoral sensors in place of radiographic film to produce instant images on a computer monitor. It also is described to require only 20% of the radiation needed for conventional radiography[24] and has the ability to control contrast, enlarge specific areas, store data on the computer, and transmit images.[6]

Only a limited number of RVG studies have been conducted that measure crown and pulpal dimensions, and no published study has been reported that utilizes RVG on primary teeth. This study was beneficial because it measured the effect of restoration on pulpal dimensions of primary second molars.

Table 2. Comparison of Coronal Pulp Dimensions in Noncarious Primary Maxillary Second Molars in Male and Female Subjects

Measurements	Male Mean±(SD)	Female Mean±(SD)	*t*-value	*P*-value
Mesiodistal crown width (mm)	9.93±0.89	9.39±0.55	2.30	<.05
Crown height (mm)	6.17±0.64	6.07±0.57	0.55	.59
Pulp width at cervix (mm)	3.15±0.53	2.90±0.46	1.62	.11
Crown width at cervix (mm)	7.49±1.03	7.03±0.45	1.83	.07
Mesial pulp horn height (mm)	2.51±0.33	2.47±0.31	0.45	.66
Distal pulp horn height (mm)	2.08±0.28	1.94±0.31	1.46	.15
Pulp area of clinical crown (mm^2)	4.90±2.15	4.93±1.02	0.06	.95
Total pulp area (mm^2)	7.96±3.34	8.25±3.57	0.26	.79
Crown area (mm^2)	57.06±13.18	47.64±10.27	1.18	.24

Table 3. Comparison of Coronal Pulp Dimensions in Noncarious Primary Mandibular Second Molars in Male and Female Subjects

Measurements	Male Mean±(SD)	Female Mean±(SD)	*t*-value	*P*-value
Mesiodistal crown width (mm)	10.60±0.96	10.36±0.48	1.00	.32
Crown height (mm)	5.58±0.66	5.35±0.58	1.20	.24
Pulp width at cervix (mm)	4.11±0.55	4.04±0.47	0.43	.67
Crown width at cervix (mm)	8.11±0.96	7.96±0.71	0.54	.59
Mesial pulp horn height (mm)	2.74±0.37	2.65±0.27	0.83	.41
Distal pulp horn height (mm)	2.22±0.26	2.27±0.28	0.59	.56
Pulp area of clinical crown (mm^2)	6.40±3.04	6.14±2.75	0.28	.78
Total pulp area (mm^2)	11.62±7.42	12.79±7.76	0.49	.63
Crown area (mm^2)	54.17±16.79	54.07±14.17	0.02	.98

Table 4. Comparison of Coronal Pulp Dimensions in Noncarious and Restored Primary Second Molars

Parameter	Control (noncarious) (N=80) Mean±(SD)	Experimental (restored) (N=80) Mean±(SD)	*P*-value
Pulp area of clinical crown	5.59±2.42	5.29±2.55	.44
Total coronal pulp area	10.15±6.20	9.76±5.04	.66
Mesial pulp horn height	2.59±0.33	2.50±0.35	.09
Distal pulp horn height	2.12±0.30	2.08±0.32	.41

Table 5. Comparison of Coronal Pulp Dimensions between Class I and II Restorations in Primary Maxillary Second Molars

Measurements	Class I Mean±(SD)	Class II Mean±(SD)	*t*-value	*P*-value
Mesial pulp horn height (mm)	2.50±0.34	2.36±0.35	0.10	.21
Distal pulp horn height (mm)	1.98±0.25	2.03±0.33	0.31	.63
Pulp area of clinical crown (mm^2)	5.81±4.46	5.11±1.72	0.26	.52
Total pulp area (mm^2)	8.34±4.19	8.59±4.18	0.43	.85

The present study's results showed that in non-carious mandibular second molar dimensions, such as mesiodistal crown width, crown height, pulp and crown width at the cervix, and distal pulp horn height, were greater compared to non-carious maxillary molars in 4-7 yrs age group in Indian population. These differences between maxillary and mandibular dimensions were significant. Conversely, when Chandler et al [5] evaluated coronal pulp dimensions in permanent first molars, they observed that total pulp areas of maxillary molars were larger than mandibular molars.

When comparing male and female subjects, significant differences were found in the mesiodistal crown widths of non-carious primary second maxillary molars. These differences were greater in males than females. Similar findings was observed in studies which revealed that mesiodistal crown diameters of second deciduous molars were significantly larger in boys vs girls.[4,17,18]

In the present study, the pulp areas and heights of mesial pulp horns in maxillary molars were reduced in restored teeth vs noncarious teeth. This agrees with the study by Chandler et al,[5] which showed that even a small restoration affects pulpal dimensions.

All the events involved in pulpal response, however, must be considered, including: carious teeth (enamel or dentinal caries); cavity preparation method; remaining dentin thickness; condition of the dentin restoration interface; presence of bacteria; application method; and toxicity of restorative material.[25-35] The relative importance of these multiple events varies between restorations and patients. These factors were not considered in present study.

No significant difference was found in the effect on pulp when comparing between Class I and II restorations in either arch. Similar results were obtained by Murray et al,[36] who concluded that the size of restorations was not closely correlated to reactionary dentinogenic activity. In contrast, however, it was found that proximal restorations in permanent teeth had a more deleterious effect on pulp dimension than occlusal restorations.[5]

The present study provides baseline data about the morphologic characteristics of the primary maxillary and mandibular second molars and also effect of amalgam restoration on pulp dimensions over a period of 6 months in 4-7 years age children. Furthermore, it is recommended that large-scale studies are required, considering all factors affecting pulp dimensions, to assess crown dimensions in primary teeth and to validate the effect of restorations on primary teeth.

CONCLUSIONS

Based on this study's results, the following conclusions can be made:

1. Crown and coronal pulp dimensions were significantly greater in noncarious primary mandibular second molars than in noncarious primary maxillary second molars.
2. Mesiodistal crown widths of noncarious maxillary molars were greater in males than in females.

Table 6. Comparison of Coronal Pulp Dimensions between Class I and II Restorations in Primary Mandibular Second Molars

Measurements	Class I Mean±(SD)	Class II Mean±(SD)	*t*-value	*P*-value
Mesial pulp horn height (mm)	2.69±0.30	2.53±0.29	0.04	.09
Distal pulp horn height (mm)	2.22±0.37	2.14±0.28	0.22	.44
Pulp area of clinical crown (mm^2)	5.64±2.23	6.48±2.34	0.13	.25
Total pulp area (mm^2)	14.84±11.20	10.57±4.18	0.06	.12

3. Variable degree of reduction in pulp dimensions were observed in restored primary maxillary and mandibular second molars vs their noncarious counterparts. However, these dimensions were not significantly reduced over a period of six months.
4. No significant difference in pulpal dimensions was observed when Class I and II amalgam restorations were compared in either arch (over a period of six months).
5. These results should be substantiated with histological investigations to reach a definitive conclusion and further evaluate the effect of restorations on coronal pulp dimensions in primary teeth.

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