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Original Research Article

Evaluation of position of maxillary impacted canine and its effect on adjacent teeth - A correlation study between panoramic radiography and cone beam computed tomography

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Abstract

Aims and Objective: The present study was undertaken to evaluate the usefulness of panoramic radiograph in determining labiopalatal position of MIPC and its effect on permanent teeth by assessing the mesiodistal position of MIPC on panoramic radiograph and by correlating it with 3D position on CBCT.

Methods: The designed study was a cross-sectional study enrolling total 60 patients of either sex with 76 impacted maxillary canines. Patients were divided into 2 groups based on age criteria i.e age groups: ≤15 years and >15 years. Evaluation of MIPC in both groups was done by digital panoramic radiograph and subjects were subjected to CBCT imaging for exact localization of MIPC and detection of root resorption of permanent incisors. The sector location on panoramic radiographs was compared with the labiopalatal position of impacted maxillary canines on CBCT. The statistical correlation between panoramic and CBCT findings was examined using the Pearson's Chi-square test.

Results: Most of the positions of MIPC were labial (35%), followed by palatal (34%) and mid-alveolus (30%). Labial MIPC on CBCT were more frequent in sectors 1, 2 and 3 and palatal MIPC were more frequent in sector 4 and 5 on panoramic radiographs. Distribution of mid-alveolus canines showed great variation with most of them located in sector 1 and 5. Root resorption of permanent incisors (28.94%) was observed in sectors 3, 4 and 5.

Conclusions: The present study recommended that labiopalatal position of MIPC and resorption of permanent incisors might be predicted using sector location on panoramic radiography.

Keywords: Panoramic radiography, Maxillary impacted permanent canine (MIPC), Cone beam computed tomography (CBCT), Root resorption, Impacted tooth.

1. Introduction

Maxillary impacted permanent canines (MIPC) are the most frequently impacted teeth after the third molars, with a prevalence ranging from approximately 1% to 3% [1-4]. The etiology of MIPC has not yet been fully defined and is controversial, possibly due to a multifactorial predisposition. Great emphasis should be given on the accurate localization of maxillary impacted permanent canine (MIPC) and early detection of its potential resorptive effect on adjacent teeth so that preventive measures could reduce the severity of the impaction and, thus avoiding possible detrimental effects. Hence accurate localization of MIPC and early detection of root resorption is imperative in treatment planning and determining prognosis of MIPC.

Various radiographic methods for localization of MIPC have been described in literature either in single or in combinations. In our study we explored the utility of single panoramic radiograph using sector analysis for localization of MIPC as it is widely used as screening radiograph for orthodontic patients and comes with the benefit of low cost and low radiation risk. The diagnostic information obtained from panoramic radiography is valuable for the overview and prediction of tooth eruption and treatment results. However, panoramic radiography has limitations in assessing the labiopalatal position of MIPC and root resorption of incisors [5]. The relatively high radiation dose and cost have restricted multi-detector computed tomography (MDCT) use in the evaluation of tooth impaction [6]. Hence CBCT is advocated as an alternative to MDCT in recent times as its radiation dose and cost is significantly lower, with the added benefit of

3D reconstruction of maxillofacial region of interest with high spatial resolution [7]. CBCT can identify and locate the position of MIPC accurately and can also assess damage to the roots of adjacent teeth and amount of bone surrounding each tooth though the 'gold standard' for the radiographic comparisons would be the true position of the canine as recorded at operation [8].

Though in past many studies were performed on MIPC using panoramic radiography or CBCT but we could find only few studies, correlating the position of MIPC on panoramic radiography with CBCT [8,9]. So we conducted this study to correlate the position of MIPC on panoramic radiography with CBCT and to analyse the labiopalatal position of MIPC and root resorption of permanent incisors relative to the mesiodistal position of MIPC on panoramic radiographs using sector classification.

2. Materials and Methods

After obtaining institutional ethical committee approval and patient's written informed consent, this cross-sectional study was conducted in 60 subjects having 76 impacted maxillary canines comprising of both sexes. The study sample was selected from patient above 13years of age with unerupted maxillary permanent canine and with erupted ipsilateral permanent lateral incisor and central incisor. Because the root of the maxillary canine is completely formed by the age of 13–15 years, patients were classified into two age groups: group I: ≤15 years and group II ≥15 years. Patients with congenital anomalies, craniofacial syndromes and endocrinopathies affecting eruption and number of teeth, patients with odontogenic tumors or cysts around MIPC, pregnant patient, panoramic radiograph of non-diagnostic quality were excluded from the study. A detailed case history and a thorough general and radiological examination and all relevant investigations were done for all the patients.

Panoramic radiograph for each patient was carried out with PLANMECA PM 2002 EC PROLINE panoramic X-ray unit in PAN mode. The radiographs were taken at 6-10mA, 66-70kV and an exposure time of 15-18 seconds with the FCR imaging plate (IP) cassette type CC- 6" X 12" adjusted in the same mode. The kVp (kilovoltage) and mA (milliamperage) were adjusted according to the age and sex of the patient to optimize the contrast. Paired panoramic radiographs and CBCT images from 60 patients were analyzed. The mesiodistal position of the MIPC tip in relation to adjacent teeth was placed into a panoramic sector classification proposed by Alessandria *et al* [10]. The sector location was assessed on 76 impacted canines of 60 panoramic radiographs (Figure 1).

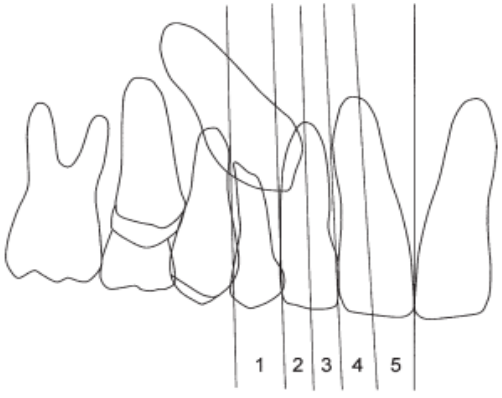

Figure 1: Mesiodistal position of canine cusp tip on panoramic radiography according to the sector location

[(1) Corresponds to the deciduous canine (absent or present); (2) indicates the distal aspect to the midline of the lateral incisor; (3) indicates the midline of the lateral incisor to the distal aspect of the central incisor; (4) indicates the distal aspect to the midline of the central incisor; and (5) indicates the midline of the central incisor to the midline of the maxillary arch]

The CBCT data volumes were reconstructed using ROMEXIS SOFTWARE VERSION 3.2.0.R (PLANMECA FINLAND) and the labiopalatal position of impacted canines and resorption of incisors were assessed in static cross-sectional reformatted images. In assessing CBCT studies, each examiner reviewed the entire volume and was allowed to reformat images. The labiopalatal position of canines was classified as labial, mid-alveolus and palatal, depending on the relative position of the canine crown to adjacent teeth. Resorption of permanent incisors was classified as no resorption or resorption. No resorption meant intact root surfaces. Sector location on the panoramic radiographs was correlated with the labiopalatal position of MIPC along with the resorption of incisors in CBCT images.

2.1 Statistical Analysis

Statistical analysis was performed using SPSS version 18.0 (SPSS INC.). The demographic data and unilateral/bilateral occurence of MIPC were presented as Mean ± SD. The distribution of MIPC was obtained in terms of number and percentages according to age, sector location and labiopalatal position. Pearson's Chi-square test was used to determine significance of correlation between- 1. Sector location and labiopalatal position of MIPC, 2. Labiopalatal position of MIPC and root resorption of permanent incisor associated with MIPC, 3. Sector location of MIPC and root resorption of permanent incisor associated with MIPC. P value ≤ 0.05 considered as statistically significant as well as p value > 0.05 considered as non-significant.

3. Observations and Results

Sixty patients were selected for the study, divided into group I and group II. Group I (≤15years) comprised of 11 subjects and group II (>15 years) consisted of 49 subjects. Table 1 show the distribution of patients according to gender and age as well as distribution of subject with unilateral and bilateral MIPC as per gender. The mean age of males and females in the study was 27.59±11.22 years and 22.33±8.94 years respectively.

Table 1: Distribution of patients according to gender and age with unilateral and bilateral MIPC as per gender

Gender	≤ 15	>15	Unilateral	Bilateral
Male (n=22)	2 (9%)	20 (91%)	17 (77%)	5 (23%)
Female (n=38)	9(24%)	29 (76%)	27 (71%)	11 (29%)
Total (n=60)	11(18%)	49 (82%)	44 (73%)	16 (27%)

In the ≤15 years old group, labially impacted canines were predominant and were more frequent in sectors 1, 3 and 4. In >15 year old group, the palatally impacted canines were most frequent and were more frequent in sectors 3, 4 and 5. For mid-alveolus position sector location varied, most of these MIPC were observed in sector 1 and 5. Further, in labial position, maximum i.e. 6 canines were observed in sector 1, followed by 4 each in sector 2 and 3. Overall, 27 (35%) canines were in labial position, followed by 26 (34%) in palatal and 23 (30%) in mid-alveolus position. As regards sector, maximum i.e. 18 (24%) canines were observed in sector 1 and 4, followed by 17 (22%) in sector 5. There was a statistically significant association between sector location and labiopalatal position of canines ($p < 0.05$), (Table 2).

Table 2: Relationship between sector location of MIPC on panoramic radiographs and labiopalatal position on CBCT images

		Labiopalatal position			
Age (years)	Sector location	Labial	Mid - alveolus	Palatal	Total
≤15	1	4	0	0	4
	2	0	1	0	1
	3	2	0	0	2
	4	2	1	1	4
	5	0	0	1	1
	Subtotal	8	2	2	12
>15	1	6	8	0	14
	2	4	3	2	9
	3	4	2	5	11
	4	2	2	10	14
	5	3	6	7	16
	Subtotal	19	21	24	64
Total	1	10	8	0	18(24%)
	2	4	4	2	10(13%)
	3	6	2	5	13(17%)
	4	4	3	11	18(24%)
	5	3	6	8	17(22%)
	Total	27(35%)	23(30%)	26(34%)	76

In ≤15 year old group, sectors 4 and 5 showed root resorption of permanent incisors. In >15 year category, there were 7 MIPC with resorption in sector 5, followed by 6 MIPC with resorption in sector 4. Resorption of permanent incisors was present in 22 patients (29%), was observed in sectors 3, 4 and 5 and showed significant differences according to sector location ($p < 0.05$), (Table 3).

Table 3: Relationship between sector location of MIPC on panoramic radiographs and root resorption of permanent incisors on CBCT images

Age (years)	Sector location	Resorption absent	Resorption present
≤15	1	4	0
	2	1	0
	3	2	0
	4	2	2
	5	0	1
	Subtotal	9	3
>15	1	12	2
	2	9	0
	3	7	4
	4	8	6
	5	9	7
	Subtotal	45	19
Total	1	16	2
	2	10	0
	3	9	4
	4	10	8
	5	9	8
	Total	54(71%)	22(29%)

In age group less than 15 years, there were 2 canines in labial position with resorption of permanent incisors. In the other age group, there were 8 canines in the mid-alveolus position associated with resorption, followed by 7 in the palatal position. Overall, there were 8 canines with resorption in mid-alveolus and palatal positions each and 6 in the labial position. The association between labial position and resorption was statistically insignificant with p-value of 0.6016 ($p > 0.05$), (Table 4).

Table 4: Relationship between labiopalatal position of MIPC and root resorption of permanent incisor associated with MIPC on CBCT images

Age (years)	Labiopalatal position	Resorption absent	Resorption present
≤15	Labial	6	2
	Mid- alveolus	2	0
	Palatal	1	1
	Subtotal	9	3
>15	Labial	15	4
	Mid- alveolus	13	8
	Palatal	17	7
	Subtotal	45	19
Total	Labial	21	6
	Mid- alveolus	15	8
	Palatal	18	8
	Total	54 (71%)	22 (29%)

4. Discussion

It is important to consider the advantages of CBCT in canine localization and its impact on patient management. Therefore, the potential improvement in the surgical management of patient with the use of CBCT imaging warrants investigation. For many years, panoramic radiography was regarded as the standard technique for the diagnosis and treatment planning for impacted canines. Previous studies have shown its utility in localization of

MIPC and prediction of root resorption [8,11,12]. In present study panoramic radiograph were used to determine labiopalatal position of MIPC as it would be advantageous to use the maximum amount of information obtained from this single film as no additional films would need to be taken further in such patients, hence reducing the unnecessary radiation exposure [13].

Several studies have compared the diagnostic information gained from panoramic versus CBCT radiography, using sectors, linear and angular measurements [14-16]. Sector location of MIPCs on panoramic radiography could be helpful in treatment planning for MIPCs. Though various studies in the literature have tried to explore the utility of sector analysis method in labiopalatal localization of MIPC by evaluating mesiodistal crown position of MIPC but conflicting results were seen. We could find only one study in the literature which was carried out on the subjects of Indian population using sector analysis method for localization of MIPC, but, in literature no previous study has evaluated the potential of sector analysis method in predicting root resorption of maxillary permanent incisors on Indian population [17]. So, the present study was conducted on the subjects of Indian population to evaluate the usefulness of the sector analysis method as a preference for localization of MIPC and prediction of root resorption on panoramic radiograph.

The prevalence of MIPC appears to vary within a range of 0.9% to 3.0% and females seem to be more affected [1,3,4]. In our study, there were more female subjects (63.33%) than males (36.67%) resulting in a ratio of almost 1.73:1. Walker and co-workers speculate that the difference in overall craniofacial growth and development between the sexes, as well as genetics, could be possible reasons for that finding. Another reason could be that girls and women seek orthodontic treatment more frequently than males. Furthermore, Zilberman and coworkers postulate that an experimental group represents a biased sample and may show higher or different gender ratios than in a true epidemiological (general) population.

In the ≤15 years of group, labially MIPCs were predominant as compared to mid-alveolus and palatal positions. In the other age group, the palatally MIPCs were much frequent (24) followed by mid-alveolus (21) and then labial (19). Overall, 27 (35%) canines were in labial position, followed by 26 (34%) in palatal and 23 (30%) in mid-alveolus position. The 63.1% of MIPC occurred in sectors 3, 4 and 5 in agreement with the findings of different authors [8,18,19]. The sector location for palatal MIPC were mostly 3, 4 and 5 with predominance of palatal MIPC in sector 4, this finding was in accordance with Jung *et al* [8]. We found that 19 out of total 26 palatal MIPC (73.07%) were concentrated in sector 4 and 5. In other words, we noted that most canines destined to become palatally impacted had cusp tips overlapping or mesial to the lateral incisor root as suggested by Lindauer *et al* [18]. MIPC located in mid-alveolus position were mostly observed in sector 1 and 5. Further, in labial position, maximum i.e. 6 canines were observed in sector 1, followed by 4 each in sector 2 and 3 which in agreement with findings of Jung *et al* [8]. 10 out of total 27 (37.03%) labial MIPC were seen in sector 1 unlike, Nagpal *et al* [20] who reported much higher number of labial MIPC (75.67%) to be located in sector 1. There was a statistically significant association between sector location and labiopalatal position of canines ($p < 0.05$). This suggests that sector location on panoramic radiography could be used to predict the labiopalatal position of MIPC.

Root resorption is not only the most common sequela of canine impaction but the most difficult to treat. The diagnosis of root resorption might further reduce complications during treatment and the presence or absence of root resorption will determine the treatment plan [21]. In our study, root resorption was associated with 22 of 76 (28.94%) MIPC. The percentage of root resorption was lower than the 30.1% reported by Jung *et al* [8], 40.5% reported by Liu *et al* [22] 38% reported by Ericson and Kurol [5] and 66.7% reported by Walker *et al* [1]. These differences may be attributed to differences in sampling and patient age. Also in the current study, out of total 22 root resorptions, 20 (90.9%) were observed in sectors 3, 4 and 5, this finding correlates with different studies [8, 23]. There was a statistically significant association between sector locations and resorption status, ($p < 0.05$). So in agreement with Jung *et al* [8] we also suggest that when canine impactions are suspected in sectors 3, 4 and 5 on panoramic radiograph, CBCT should be considered for those with suspected incisor resorption as root resorption of permanent incisors cannot be accurately judged from conventional radiography alone. CBCT imaging is significantly better than that of panoramic radiography for determining root resorption.

In the present study almost 90% root resorptions were associated with MIPC located in sectors 3, 4 and 5. So, when canine impactions are seen in sectors 3, 4 and 5 on panoramic radiography, CBCT should be considered for those with suspected incisor resorption as root resorption of permanent incisors cannot be accurately judged from conventional projection radiography alone. Hence, sector analysis of MIPC on panoramic radiograph can guide the practitioner in determining use whether CBCT is indicated or not. Because indiscriminate use of CBCT is not recommended in all cases of MIPC, considering the possibility of higher levels of radiation exposure from its routine use and its limited availability.

There are some limitations of the study which include- 1. The sample studied in this research is not sufficient to represent the entire population. 2. The narrow image layer in the anterior region on panoramic radiograph sometimes results in distortion/blurring of image in this region making the evaluation of MIPC cusp tip difficult. 3.

Moreover, the sectors were drawn manually, thus, the sectors lacked standardization and were subjected to variation.

5. Conclusion

Labial MIPC on CBCT were more frequent in sectors 1, 2 and 3 and palatal MIPC were more frequent in sector 4 and 5 on panoramic radiographs. Resorption of permanent incisors was observed in sectors 3, 4 and 5. When maxillary canines are impacted in sectors 3, 4 and 5 on panoramic radiographs, CBCT scans would be appropriate to localize the labiopalatal position of impacted canines and assess any root resorption. The labiopalatal position of MIPC and resorption of permanent incisors might be predicted using sector location on panoramic radiography. However more research consisting of larger sample population is needed in order to support this view and substantiate these findings.

For future point of view it is suggested that 1. Larger sample size would further help in assessing the usefulness of panoramic radiograph in determining labiopalatal position of MIPC and its effect on permanent teeth by sector analysis method. 2. In localization of aberrantly placed canines, utility of sector analysis method on panoramic radiograph should be evaluated for further studies.

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