Turkish Online Journal of Qualitative Inquiry (TOJQI)
Volume 12, Issue 9, August 2021: 1321-1331

3D Evaluation of Impacted Teeth in Maxillomandibular Region Using CBCT

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ABSTRACT

The aim of the study was to evaluate the degree and complexity of impacted teeth using 3-dimensional analysis on CBCT. Objectives were to evaluate the position and angulation of impacted teeth in 3 dimensions and any pathology with respect to impacted tooth. The study was conducted on 31 patients who presented with impacted teeth except 3rd molars. All the conventional records along with CBCT were taken and evaluated Out of 70 teeth evaluated; in maxilla, there were 8 incisors, 34 canines and 1 premolar and in mandible, 14 canines, 3 incisors and 10 premolars. Along the x- axis, 33 canines, 4 incisors and 1 premolar were impacted mesiodistally impacted.In mandible, 8 impacted canines and premolars were mesiodistal and 02 incisors were distomesial. Along the Y- axis, in maxilla, position of impaction was 14 canines at cervical 1/3rd of adjacent tooth root, 03 incisors at middle 1/3rd, 03 were at apical 1/3rd. In mandible, 07 impacted canines were at middle 1/3rd, 02 incisors at cervical 1/3rd and 06 premolars at middle 1/3rd of adjacent tooth root. Along the z axis, in maxilla, 22.9% were buccal, 27.1% palatal and 11.4% midalveolus. In mandible, 2.9% were buccal, 11.4% lingual and 24.3% midalveolus. Prevalence of impacted canine was found to be highest all impactions. Along the x-axis, mesiodistal position was the most common. Along the y-axis, most of the impacted teeth were at middle 1/3rd of adjacent tooth root. along the z- axis, most common position was the midalveolus.

Keywords

Cone beam computed tomography, Impacted teeth, Impactions, Three- Dimensional analysis, Three-Dimensional location

Introduction

Impactions usually occur due to insufficiency in space or the presence of an entity which impedes its path of eruption.[1] Apart from third molars, maxillary canines are the most commonly impacted teeth, followed by the second premolar, maxillary central incisors, mandibular cuspids, second molars, lateral incisors and the least frequently impacted are the first premolars.[2] In female patients, the

impaction occurs more commonly than male patients, some authors reported occurrence in females twice as high in males.[2-4]

According to Dachi and Howell,[4] the incidence of patients with at least one impacted tooth was 16.7% in North American population. For maxillary canines, it was 0.92%, with the range of 0.8-2.8%.[5,6] The mandibular canine impaction is less common having frequency of 0.05-0.4 percent.[7,8] Overall frequency of premolar impaction in adults has been reported to be 0.5 percent. Frequency of maxillary 2nd premolar has been found to range from 0.1- 0.3 percent.[9] Rate of prevalence of second molar impaction reported is 0-2.3%.[10] First molar impaction is rare, with incidence rates of 0.02% for the maxillary and of less than 0.01% for the mandibular.[11]

Systemic causes for impaction include febrile diseases, endocrinal insufficiencies, irradiation or may be associated with syndromes which affect multiple systems.[12] Syndromes associated with impacted teeth may be cleidocranial dysostosis, Gardner syndrome, hypophosphatasia and Yunis- Varon syndrome. Local causes may be tooth size arch length discrepancies, prolonged retention or early loss of the deciduous teeth, abnormal position of the tooth bud, the presence of an alveolar cleft, ankylosis, a cystic or neoplastic transformation of the follicle of the unerupted tooth, dilaceration of the root, iatrogenic origin and idiopathic condition with no apparent cause.

Diagnosis of an impacted tooth requires complete evaluation of all the records. Clinically, the dental age of the patient can be recorded and the area of missing tooth can be assessed for the bulge of soft tissue. However, radiological examination is essential for accurate diagnosis of an impacted tooth. Panoramic radiographs give an overview regarding the initial diagnosis, localization, treatment plan and its outcome. But the information provided by the panaromaic radiographs is inadequate as it has drawbacks of blurred images, distortion, magnification, structural superimpositions and presence of an artifact leading to misinterpretation. Hence CBCT is the preferred choice for accurately diagnosing impactions.

Hence this study was designed to evaluate the impacted teeth in maxillomandibular region and its relation to adjacent structure, using CBCT.

Methods

Design

The study was conducted on 31 patients who presented with at least 1 impacted tooth, in the Department of Orthodontics and Dentofacial Orthopedics, Faculty of Dental Sciences, SGT University, Gurgaon after the approval from Ethical committee. Total of 350 patients were screened from the OPD section of the Department of Orthodontics from November 2018 to November 2020 who reported for routine orthodontic treatment and 31 patients were found having impacted teeth.

The inclusion criteria for the subjects were; any unilateral or bilateral impaction except third molars and no prior orthodontic treatment. The exclusion criteria included; evidence of systemic disease affecting bone health, patient with only third molar impaction or evidence of motion or any other significant artifact in the CBCT scan.

Data Collection Tools

Total 70 impacted teeth were found in 31 patients. Pretreatment CBCT were done for all included patients on Planmeca 3D Mid ProFace CBCT scanner (Planmeca, Helsinki, Finland), operated at 90 kV and 14 mA, with a field of view (FOV) of 200mmx160mm.The voxel size of the scans is 150 µm. The slice thickness is 0.200mm. The DICOM (Digital Imaging and Communications in Medicine) images obtained were then analyzed using Planmeca Romexis software version 5.0.0 (Planmeca, Helsinki, Finland) in a partially darkened room. All the scans when opened were displayed on the Multiplanar Reconstructed View (MPR), showing axial, sagittal and coronal views.

Research process

Following parameters were evaluated with respect to all impacted teeth:

Location of Impacted Tooth

Three-dimensional location of the impacted tooth was determined in the three planes: Horizontal plane (X-axis), Vertical plane (Y-axis), Axial plane (Z-axis). The mesio-distal position of the impacted tooth was assessed with respect to the midline in each quadrant on CBCT generated OPG in Horizontal plane (X-axis). It was either mesiodistal, distomesial, inverted vertically impacted or horizontally impacted (Figure 1).

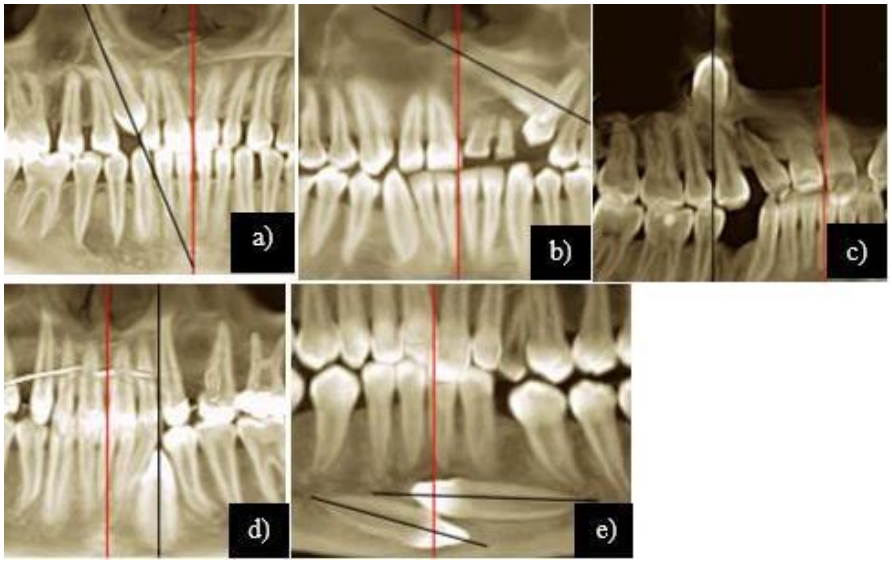

Figure 1: Position of impacted tooth in the horizontal plane (X-axis) a) Mesiodistal, b) Distomesial, c) Inverted, d) Vertical, e) Horizontal

Five horizontal reference lines were drawn for all teeth dividing them into 5 zones in vertical plane (Y-axis): between occlusal plane and cemento-enamel junction, cervical 1/3rd of root, middle 1/3rd of root, apical 1/3rd of root beyond the apex (Figure 2). This indicated the distance of impacted teeth from occlusal plane; higher the tooth level, greater was the complexity of impaction.

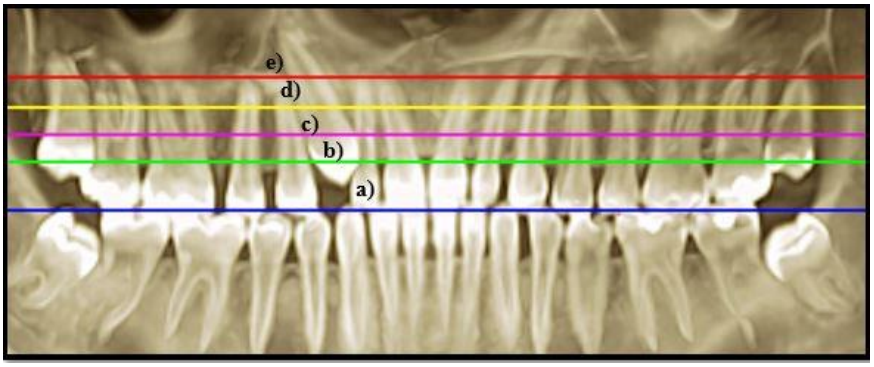

Figure 2: Position of impacted tooth in the vertical plane (Y-axis) (a) Cusp tip between occlusal plane and cemento-enamel junction of incisor, (b) at cervical third of incisor root, (c) at middle third of incisor root, (d) at apical third of incisor root, (e) beyond the apices of incisor root

The buccal- palatal position of the impacted tooth was determined in the axial view (Z- axis) of CBCT as suggested by the outline of the occlusal arch, which was drawn as a curve passing through the central fossa of posterior teeth and biting edges of anterior teeth of both sides (Figure 3). It was either buccal, palatal or midalveolus in maxillary and mandibular arch.

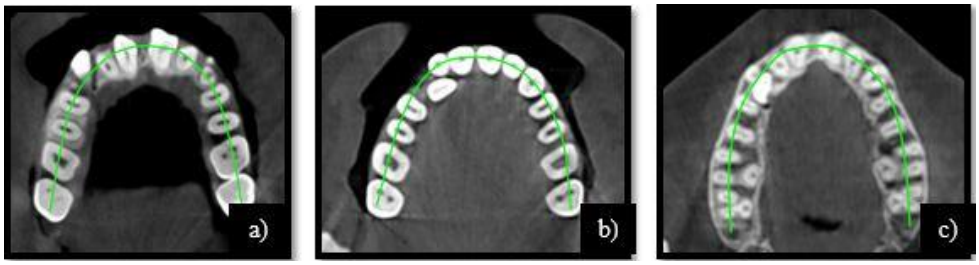

Figure 3: position of impacted tooth in the axial plane (Z-axis) (a) buccal, (b) palatal and (c) midalveolus

The Degree of Impaction

The degree of impaction was determined by measuring the angulation of the impacted tooth on coronal and sagittal view. In both views, perpendicular distances of the cusp and root tip of the impacted tooth and the angulation of the impacted tooth was measured by drawing a line passing through the long axis of the impacted tooth to the occlusal plane in sagittal view and to the midline in coronal view (Figure 4).

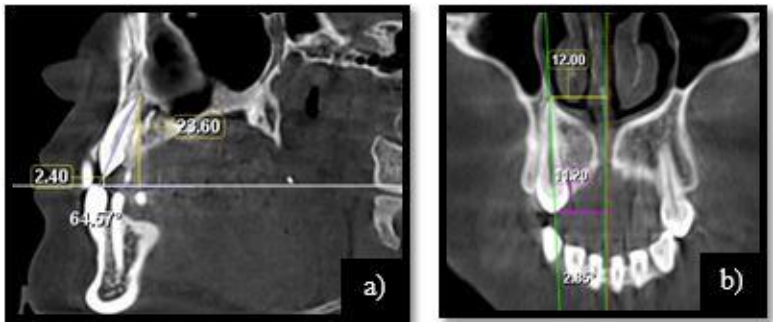

Figure 4: Linear and angular measurement with respect to (a) occlusal plane in sagittal view, (b) midline in coronal view

Associated Dental pathology

Other factors associated with the impacted tooth such as presence of root resorption, enlarged dental follicle, dilacerations and presence of odontome or supernumerary tooth were analyzed in sagittal, coronal and axial views (Figure 5).

Figure 5: Associated Dental pathology a) root resorption in sagittal view, b) enlarged dental follicle in sagittal view, c) dilaceration in sagittal view, d) supernumerary tooth in coronal view

Data collected were tabulated using Microsoft excel and were analyzed using SPSS (Statistical package for social sciences) version 2.0. Descriptive statistics of the explanatory and outcome variables were calculated by mean and standard deviation for quantitative variables, frequency and proportion was calculated for qualitative variables. Formulas employed for calculation of various values were mean/average and standard deviation.

Results

In 31 subjects, 70 impacted teeth were found, out of which 43 (61.4%) were in maxilla and 27 (38.6%) in mandible. In maxilla, there were 8 (11.4%) incisors, 34 (48.6%) canines and 1 (1.4%) premolar. In mandible, 14 (20 %) canines, 3 (4.3%) incisors and 10 (14.3%) premolars were found (Table 1).

Table 1. Percentage incidence of impacted teeth in maxillary and mandibular arch

n= number of teeth	Tooth	Number	Percentage
Maxillary	**Canine**	34	48.60%
	Incisors	8	11.40%
	Premolar	1	1.40%
Mandibular	**Canine**	14	20%
	Incisors	3	4.30%
	Premolar	10	14.30%
Total		70	

Along the X-axis, it was observed that, in maxilla, 33 (97.1%) impacted canines, 4 (50%) of impacted incisors and the only impacted premolar were mesiodistal in position. In mandible, 8 (57.1%) impacted canines and 08 (80.0%) premolars were mesiodistal and 02 (66.7%) impacted incisors were distomesial. Along the Y- axis vertical location of impacted canine from occlusal plane was observed. In maxilla, 14 (41.2%) impacted canines were at cervical 1/3rd of adjacent tooth root, 03 (37.5%) impacted incisors were at middle 1/3rd of adjacent tooth root while, 03 (37.5%) were at apical 1/3rd of adjacent tooth root. The only premolar was found at middle 1/3rd of adjacent tooth root. In mandible, 07 (50.0%) impacted canines were at middle 1/3rd of adjacent tooth root, 02 (66.7%) impacted incisors were at cervical 1/3rd of adjacent tooth root and 06 (60.0%) impacted premolars were at middle 1/3rd of adjacent tooth root. Along the Z-axis, 16 (47.1%) impacted canines and the only impacted maxillary premolar were palatal, 06 (75.0%) of impacted maxillary incisors were positioned buccally impacted. In mandible 10 (71.4%) impacted canines and 07 (70.0%) impacted premolars were midalveolus. All the impacted mandibular incisors were lingually impacted (Table 2).

Table 2. Descriptive 3D location of Impacted tooth in maxillary and mandibular arch

			3D location: x-axis					3D location: y-axis					3D location: Z-axis		
n= number of teeth		Total (n= 70)	Mesiodistal *	Distomesial **	Vertical	Inverted	Horizontal	Between occlusal plane and CEJ	At cervical 1/3rd of adjacent tooth root	Middle 1/3rd of adjacent toothoot	Apical 1/3rd of adjacent tooth root	Beyond the apices of adjacent tooth root	Buccal	Palatal/ Lingual	Midalveolus
n%= percentage distribution		n (%)	n (%)	n (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)
Maxillary (n=43)	Canine	34 (100.0)	33 (97.1)	00 (0.0)	00 (0.0)	01 (2.9)	00 (0.0)	06 (17.6)	14 (41.2)	08 (23.5)	04 (11.8)	02 (5.9)	10 (29.4)	16 (47.1)	08 (23.5)
	Incisors	08 (62.5)	04 (50.0)	02 (25.0)	00(0.0)	01 (12.5)	01 (12.5)	00 (0.0)	01 (12.5)	03 (37.5)	03 (37.5)	01 (12.5)	06 (75.0)	02 (25.0)	00 (0.0)
	Premolar	01 (100.0)	01 (100.0)	00 (0.0)	00 (0.0)	00 (0.0)	00 (0.0)	00 (0.0)	00 (0.0)	01 (100.0)	00 (0.0)	00 (0.0)	00 (100.0)	01 (100.0)	00 (0.0)
Mandibular (n=27)	Canine	14 (100.0)	8 (57.1)	02 (14.3)	02 (14.3)	00 (0.0)	02 (14.3)	00 (0.0)	04 (28.6)	07 (50.0)	00 (0.0)	03 (21.4)	02 (14.3)	02 (14.3)	10 (71.4)
	Incisors	03 (100.)	00 (0.0)	02 (66.7)	01 (33.3)	00 (0.0)	00 (0.0)	00 (0.0)	02 (66.7)	01 (33.3)	00 (0.0)	00 (0.0)	00 (0.0)	03 (100.0)	00 (0.0)
	Premolar	10 (100.0)	08 (80.0)	01 (10.0)	01 (10.0)	00 (0.0)	00 (0.0)	00 (0.0)	02 (20.0)	06 (60.0)	02 (20.0)	00 (0.0)	00 (0.0)	03 (30.0)	07 (70.0)

Linear and angular measurements of impacted tooth with respect to occlusal plane in sagittal view and midline in coronal view is shown in (Table 3). Greater the distance from occlusal plane, more complex was the impaction. Increased angulation to midline showed increased complexity of impaction.

Table 3. Linear and angular measurement of impacted tooth with respect to occlusal plane and midline in maxillary and mandibular region

n= number of teeth		Distance of impacted tooth from occlusal plane in sagittal view (in mm)				Angulation of impacted tooth to the occlusal plane in sagittal view (in degrees)		Distance of impacted tooth from midline in coronal view (in mm)				Angulation of impacted tooth to the midline in coronal view (in degrees)	
		cusp tip		root tip				cusp tip		root tip			
		Mean	Sd	Mean	Sd	Mean	Sd	Mean	Sd	Mean	Sd	Mean	Sd
Maxillary (n=43)	**Canine**	9.7	6.06	25.97	4.13	50.14	18.34	10.12	4.13	14.74	2.18	18.88	24.81
	Incisors	14.51	5.8	22.12	5.87	85.9	54.18	3.54	4.41	7.63	5.07	20.25	12.78
	Premolar	13	-	23.8	-	38	-	11.4	-	13.76	-	52	-
Mandibular (n=27)	**Canine**	12.48	6.4	28.45	3.75	61.11	29.32	6.66	5.97	11.79	3.87	20.89	24.06
	Incisors	6.8	2.8	29	2.31	85.17	7.92	2.33	1.7	2.13	3.5	8.67	4.88
	Premola	10.66	3.63	29.4	3.35	75.19	20.07	15.4	2.69	20.371	5.22	33.89	34.55

Dental pathology; root resorption, dilaceration, enlarged dental follicle and supernumerary teeth observed with respect to impacted teeth are shown in (Table 4).

Table 4. Dental pathology associated with impacted tooth

n= number of teeth		Total	Pathology				
			Root resorption	Dilaceration	Supernumerary	Enlarged Dental follicle	Absent
		(n=70)	(n)	(n)	(n)	(n)	(n)
Maxillary	**Canine**	34	7	4	0	1	22
	Incisors	8	0	3	4	0	1
	Premolar	1	0	0	0	0	1
Mandibular	**Canine**	14	0	3	0	0	11
	Incisors	3	0	1	0	0	2
	Premolar	10	0	1	1	0	8

Discussions

Many researchers previously have localized impacted teeth on panoramic radiographs using various techniques.[13-15] Even though panoramic radiographs have been used often for diagnosis of impacted

canines, they can be inaccurate as they are two-dimensional views. There might be distortion or overlapping of structures, causing misinterpretation and inability to visualize individual structures. Cone beam computed tomography (CBCT) provides three-dimensional view of the dentition and jaws with lower radiation dose as compared to conventional computed tomography (CT). Hence, CBCT was used in this study to identify three-dimensional location and angulation of impacted teeth.

Prevalence rate reported in this study was 8.8%. Patil et al [3] observed 16.8% of prevalence rate in North Indian population. In a recent study by Alamri et al [16] on Saudi population, the prevalence rate of impacted teeth was found to be 13.2%, whereas in Greek population, the rate was found to be 13.7% [17] More impactions were found in maxilla than mandible. This could be because growth of maxilla stops earlier than mandible, leading to discrepancy in arch length. In both the arches, impacted teeth were found more on the left side as compared to right side. This finding is supported by a study by Zoubi et al [18] and Takahama et al [8] who also reported higher incidence of impactions on left side. Even though, there are no scientific reason to explain it, genetics could be considered to play a role. Females to male ratio in this study was found to be 1.8:1. This could be because the craniofacial growth and development is found to be different among the sexes. Since growth completes earlier in females, they might have narrower arches, causing decreased intercanine and intermolar width and hence increasing the probability of impactions. Another reason could be that patients reporting for orthodontic treatment are mostly females, as they are more concerned about their esthetics.

Most common impacted tooth was the maxillary canine (48.6%), followed by mandibular canine (20%). The results are in agreement with previous studies, which also stated that maxillary canines have higher prevalence rate of impaction.[2,19-21] This may be due to the fact that canines have the longest path of eruption, leading to disrupted pathway. Also, environmental factors like trauma, absence of lateral incisors, root dilaceration, crowding, supernumerary teeth or odontomes could be the reason for increased number of impacted canines.[22] Studies by Peck et al [4] and Mossey PA[23] have found genetic influence on canine impaction. In this study, 25.7% of impacted teeth were buccally impacted which were less complex than 35.7% impacted teeth that were midalveolus and 27.2% impacted teeth that were located palatally in maxilla and 11.4% lingually impacted teeth in mandible.

Most of the impacted teeth (77.1%) observed were located mesiodistally which are easier to treat orthodontically. Greater the mesial inclination of impacted tooth, more is the complexity as it leads to horizontal positioning of impacted tooth. Grisar et al [24] in their study suggested that, mesioangular or vertical positioned impacted teeth can be treated by surgical exposure and orthodontic traction. Second most common position found in this study was the distomesial (10%), where the root is mesial compared to crown, hence difficult position to treat. Frequency of inverted or horizontally impacted teeth were less and are the most complex position of impacted teeth to treat. The choice of treatment in these cases would be extraction of these impacted teeth as they have very poor prognosis. Autotransplantation may be considered in case of horizontally impacted teeth.[25]

Location of the impacted tooth from the occlusal plane is considered as an important predictor for the prognosis as well as determining the treatment time for the impacted tooth. 8.6% impacted teeth were located between the occlusal plane and CEJ of adjacent tooth root and 32.8% were within the cervical 1/3rd of adjacent tooth root which can be considered to be mildly complex. 8.6% impacted teeth were located beyond the apices of adjacent tooth root which were considered to be severely impacted.[26]

As the distance of the cusp tip of impacted tooth increases from the occlusal plane, more difficult it will be to bring them into the arch. In this study, an impacted tooth at a distance of less than 5 mm from the occlusal plane was considered as mildly complex to treat; 5-15 mm from the occlusal plane as moderately complex and impacted tooth at distance greater than 15mm from the occlusal plane was considered as severely complex. In this study, it was found that 11.4% were between 15-20mm from the occlusal plane and 5.7% were at a distance of more than 20mm from occlusal plane. Closer the impacted tooth to the occlusal plane, easier would be its treatment.

Angulation of the impacted tooth with respect to the midline is an important parameter for the risk of impaction.[27] As the angulation to midline increases, the risk of impaction increases, leading to increased complexity of impaction and longer treatment time. In this study, 18.6% impacted teeth were having angulation more than 31°. Powers et al [28] stated that if the angulation of an impacted tooth to the midline is more than 31°, then the chances of the impacted tooth to erupt after extraction of its deciduous predecessor is reduced. Studies by Yan et al [29] and Jung et al [27] confirmed that if the angulation of a tooth to midline is above 30°, then there are high chances of impaction.

In this study, root resorption was seen only with 7 impacted canines out of 70 (10%) impacted teeth. Ericson stated that due to contact of impacted canines to the adjacent tooth root, it applies active physical pressure on the adjacent tooth root causing cellular changes in the cementum of the root, leading to its resorption.[30] Root dilaceration was observed in 17.1% of impacted teeth. Impacted incisors are generally associated with root dilaceration, which may occur due to any trauma to the developing tooth. Supernumerary teeth were found in 7.1% of impacted teeth, the most commonly found supernumerary teeth were the mesiodens, causing impaction of incisors. Dental follicle was considered to be in normal limits if its width ranged from 0-2mm, but if width of dental follicle is more than 2mm, it was considered to be enlarged, which was seen in association with only one impacted canine. The enlarged dental follicle may undergo cystic changes, which may lead to dentigerous cysts. Hence size of dental follicle should be examined for each impacted tooth to avoid severe complications.

Diagnosis of Impactions is an important aspect in treatment planning for orthodontic patients. With CBCT, the correct position of an impacted tooth can be defined and other complexities like ankylosis, dilaceration and root resorption which affects the treatment outcome can be easily identified. This study emphasised the three-dimensional location of impacted teeth, however further studies with increased number of patients are encouraged to find associated root resorption and dental pathologies.

Conclusion

Prevalence rate of impacted teeth except 3rd molars, was found to be 8.8%. Impactions occurred more in maxilla as compared to mandible and left side was affected more than right side. Females to male ratio was found to be 1.8:1 for impacted teeth. Maxillary canines had the highest frequency of impaction (48.6%) followed by mandibular canines (20%), mandibular premolars (14.3%), maxillary incisors (11.4%), mandibular incisors (4.3%) and the impacted tooth with least frequency of impaction was maxillary premolar (1.4%). In maxilla, 22.9% were buccal, 27.1% palatal and 11.4% midalveolus. In mandible, 2.9% were buccal, 11.4% lingual and 24.3% midalveolus. 40% impacted teeth were between 5-10mm from occlusal plane, 30% impacted teeth were between 10-15mm from occlusal plane (moderately complex), 12.9% impacted teeth were at a distance of less than 5 mm from the

occlusal plane (mildly complex), 11.4% were between 15-20mm from the occlusal plane and 5.7% were at a distance of more than 20mm from occlusal plane (severely complex). Most common pathology found was root dilaceration (17.1%), followed by root resorption of adjacent tooth (10%), presence of supernumerary teeth, (7.1%) and enlarged dental follicle seen in 1(1.4%) maxillary canine.

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