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THE ADVANTAGES OF USING CONE BEAM CT TO DETERMINE THE POSITION AND RESORPTION OF MAXILLARY CANINES

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Abstract:
Objective. *The aim of this research is to find the neighboring incisors resorption and maxillary canines' impacted locations using "Cone-beam Computed Tomography" or CBCT.*
Study Design. *A number of 210 IMC were examined through CBCT images. New Tom (propriety software) was used to take linear and angular measurements after locations of IMC were evaluated. Also, the investigation of NI of root resorption was carried out.*
Results. *The results showed 45.20% buccal-labially impacted, 14.30% midalveolus, and 40.50% palatally impacted. A varied location included n_8 inverted impactions, n_18 horizontal impaction, n_31 situ impaction, n_12 distal impactions, n_67 mesial-labial impactions, and n_74 mesial-palatal impactions. Quantitative measurements resulted a 27.20% of root resorption of lateral, central incisors 23.40% and 94.30% of resorptions were observed due to close contact of impacted canines with incisors.*
Conclusion. *IMC location variation occurs in three planes greatly and resorption is common of permanent NIs.*
Keywords: *Cone-beam computed tomography (CBCT), Maxillary Canines (MCs), Impacted Maxillary Canines (IMCs), Incisors Resorption (IR), Neighboring Incisors (NIs), three dimensions (3-D), Mesial-Labial Impaction (MLI), and Mesial-Palatal Impaction (MPI).*

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INTRODUCTION:

The definition of impaction is "a tooth eruption failure at its suitable location in dental arch, within its normal growth period". IMCs being prevailed from one to three percent approx. are the second frequent teeth impaction after 3rd molars. The importance of MCs is more functionally but treatment of ICs is time-taking and difficult. Also, ICs location and inclination vary which easily leads cystic degeneration and to NIs resorption. Exact localization with accurate diagnosis of ICs is necessary for managing surgical-orthodontic. Radiographic techniques like occlusal, periapical, cephalometric, and panoramic radiographs or a combination of these have been recommended before [1]. Due to the complex, overlapping structure in maxillofacial region, using the above techniques showed inaccurate dental structures, therefore, computed tomography (spiral) was used by authors to localize impactions and evaluate IR through 3-D imaging and perfect tissue contrast achieved using this technique. On the other hand, high cost and radiation restricts the use of this technique in evaluating impaction of tooth. Recently, the development of CBCT units, which produce radiation in cone shape to collect maxillofacial region information using significantly less radiation with 3-D resolution, made tooth impactions easy and accurate. Regardless all this, orientation of ICs and 3-D locations are needed to be analyzed comprehensively [2]. This research tends to quantify and evaluate inclination and location of IMCs to determine IR of root through CBCT imaging using retrospective analysis in subject size of 175.

MATERIAL AND METHODS:

A sample size of 175 subjects with IMCs (July 2014-August 2017) referred for locating teeth impaction using CBCT. CBCT images (210) of ICs were collected and studied retrospectively from CT unit. Earlier studies can be consulted for structure, process of reconstruction and imaging. Primary reconstruction and occlusal plane are aligned parallel for plane. To inspect relationship of dental structure and peripheral bony and ICs, a range of forty to fifty axials of reconstruction volume is set. Resulted data of images was analyzed through NewTom. For each subject, the following data was evaluated: (1) Impaction variations in 3-D, vertical inclination, mesiodistal migration, location of buccolingual crown respectively; (2) Location and inclination of ICs to structures of maxilla were measured in angular and linear, made on trans-axial and axial using Walker et al. method; (3) More than 3 millimeter distance were recorded only while measuring area from periphery of follicle to crown; and finally, (4) contact of ICs to IR and incisors where IR was assessed by trans-axial and axial view, categorizing it on the basis of Ericson and Kurol grading system which is no resorption, mild, moderate and severe resorption meaning root surfaces intact, unbroken pulp lining, exposed pulp due to resorption with root length lesser than 1/3 of entire root and exposed pulp due to resorption with root length more than 1/3 of entire root. In NewTom toolbar (distance calibration) 3-D view defined longitudinal axis of IC which connected root apex and cusp tip automatically when user selected two points which created trans-axial view. Calculation of angle between midline and canine, and midline of maxilla to cusp tip were taken on axial plane (Fig. 1, A). Angle between occlusal plane and canine was measure through trans-axial view (Fig. 1, B). Zone of dental arch to cusp tip was divided in cervical, apical and middle 1/3 of root, coronal, and supra-apical categories. Additionally, control group of 30 subjects with normal erupted canines was selected randomly with similar measurements taken twice by D.G. L. (1st author) and using mean.

SPSS software was used for statistical analysis. For comparison between impaction variations and a group of thirty normal erupted canines, a test was conducted. To compare impaction variation differences for vertical zone, a "chi-square" test was carried out. The same test was used to analyze root IR to evaluate canine and incisors contact association. Significance level P_.050 was set. Reproducibility and reliability determination of finding long axis of ICs, occlusal plane and linear and angular measurements was achieved by taking 10 ICs cases randomly, performing CBCT images twice with 24 hours' gap, aligning plane to occlusal plane. Reconstructed imaging set was measured and traced twice with at least one-day gap. Duplicate measurements were analyzed variance on complete-block design.

RESULTS:

With 55 males and 120 females subject size was totaled as 175. From ten to fifty-nine years' age, mean 16.90-6.90 with 14 years' median. Patients with unilateral ICs were 140 (left: 53, right: 87) and bilateral ICs were thirty-five (Table I). One patient with odontoma near IC and 2 with supernumerary teeth reported. The 3-D image of CBCT taken, occlusally oriented ICs were 184 (67 with mesial-labial impaction Fig.1, 31 with mesio-distal in situ Fig.3, 74 with mesial-palatal Fig.2, and 12 with distal impactions to molar region Fig.4). Eighteen ICs were oriented horizontally to occlusal plane (Fig. 5), and eight were oriented apically (Fig. 6).

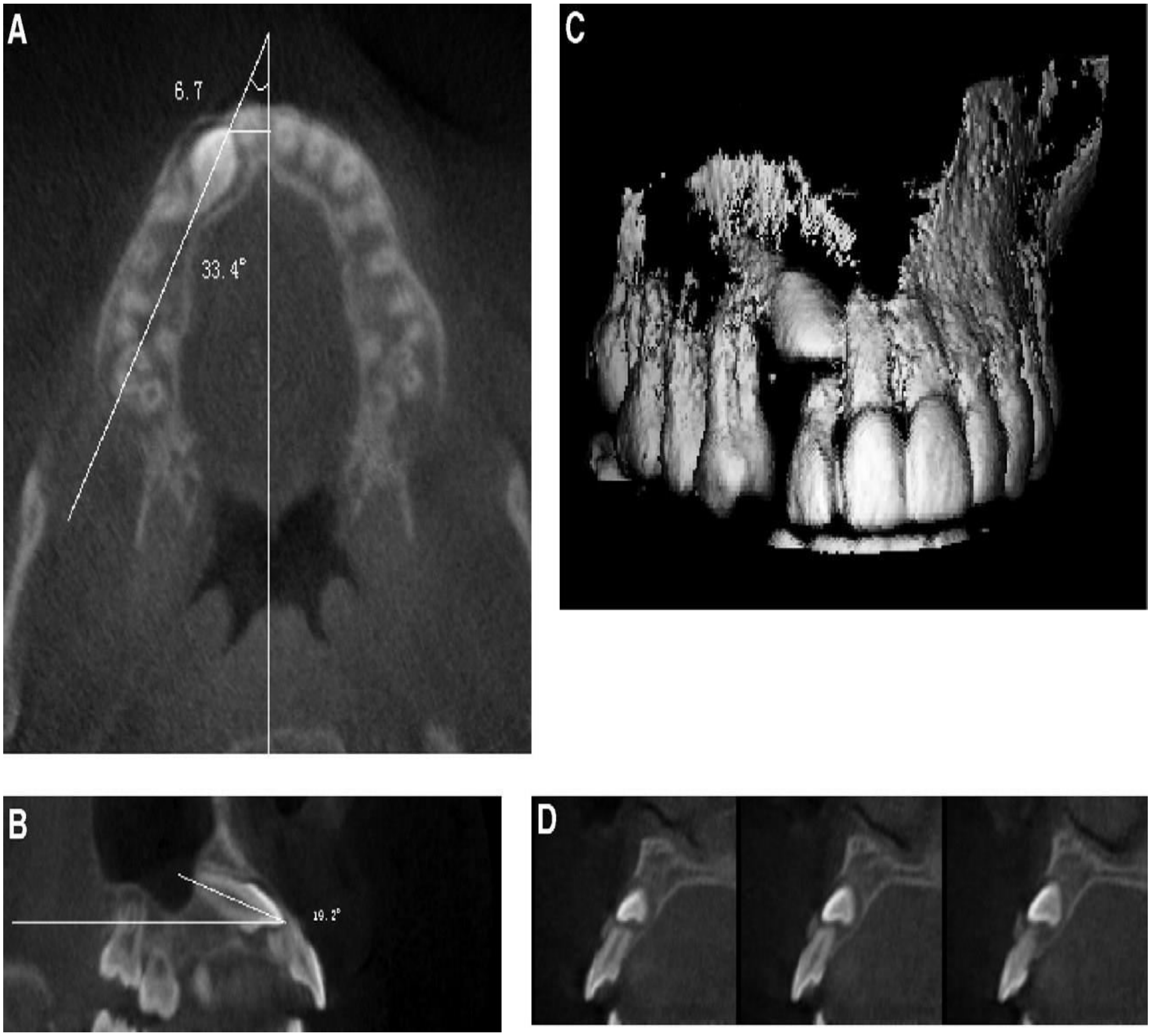
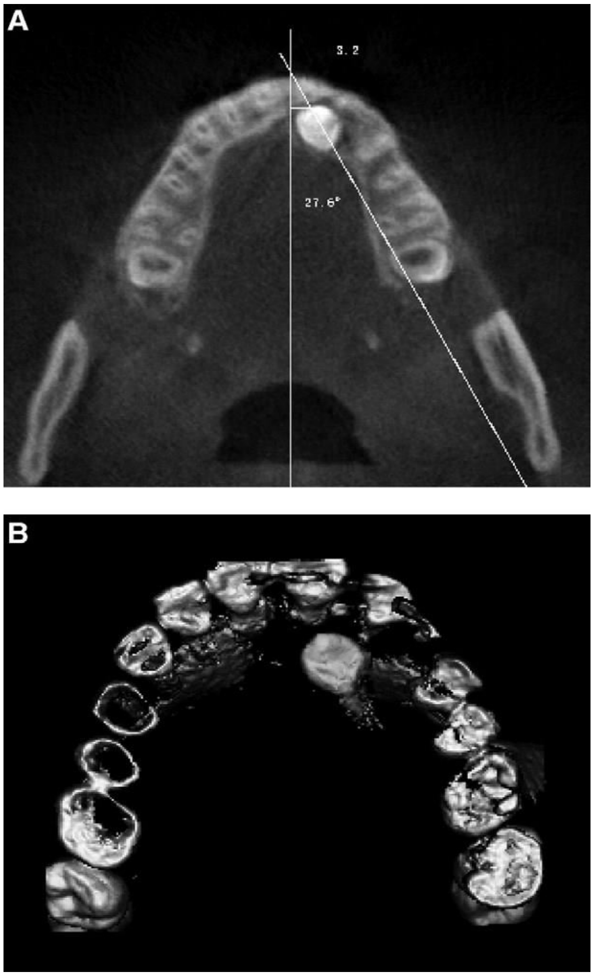


Fig. 1. A, impacted tooth 6 in contact and distally situated with tooth 8 with 33.40° to midline and 6.70 millimeter distance from midline to cusp tip **B,** an angle (vertical) of 19.20° of occlusal plane to tooth 6 in trans-axial view **C,** Mesio-labial situation of IC to 7th tooth in 3-D View **D,** showing severe resorption, root apex of 7th tooth is labially located to cusp of tip of 6th tooth, as shown through trans-axial view.

Table I. MCs distribution (sex/age wise) in 175 subjects

Gender	Number	Age			Impact Canines		
		Range	Mean	±SD	Unilaterally	Bilaterally	Total
Male	55	10 to 59	17.1	7.8	43	12	67
Female	120	10 to 45	16.7	6.5	97	23	143
Total	**175**	**10 to 59**	**16.9**	**6.9**	**140**	**35**	**210**

Fig. 2. 3-D view shows palatal position of 9th, 10th to 11th tooth in **A&B.**



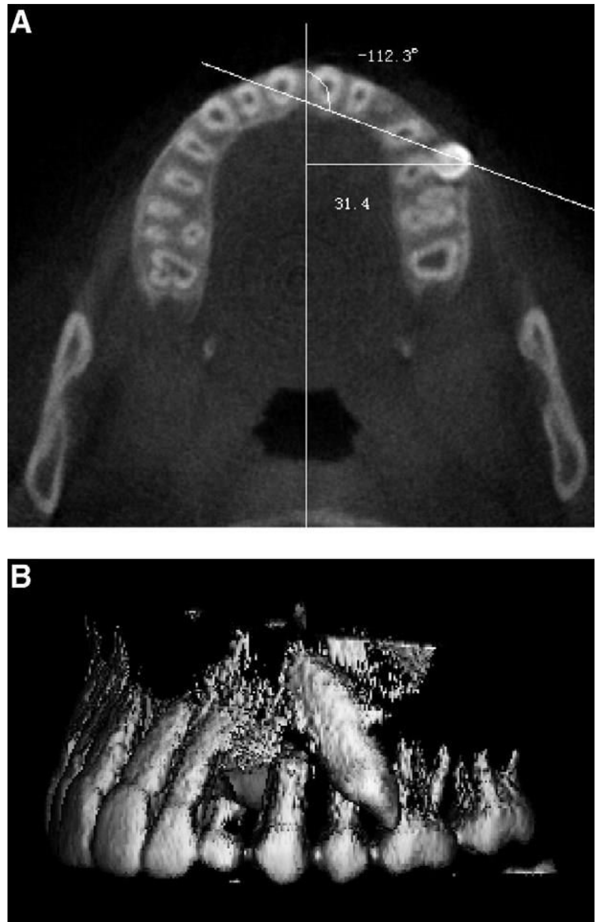


Fig. 3. 3-dimensional view of 6th tooth in mesio-distal location in situ.

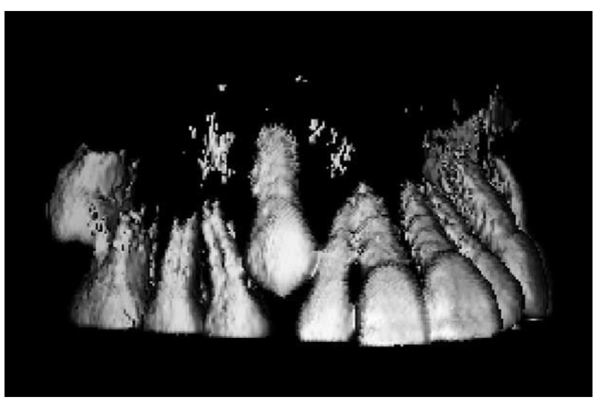


Fig. 4. A, Tooth 13 and cusp tip of 11th tooth buccal-aspect location with an angle (Horizontal) of 112.30° and 31.41 millimeter distance of midline to canine. **B,** Relationship of dental arch to distal-buccal canine in a 3-D view. Location of crown (anterior/posterior) were observed in incisor regions as, 67 lateral, 75 in central, 2 in anterior maxillary sinus, 17 in premolar, 35 in mesio-distal in situ, and 14 between lateral and central. Additionally, distribution of location of buccolingual crown was observed as 45.20% (95) labial ICs, 40.50% (85) palatal ICs, and 14.30% (30) alveolus ICs. Variance analysis test shows duplicate measurements with increased reliability. Inter-

class correlation coefficient was (R value= 0.9980), (0.9930), and (0.9990) for horizontal, linear and vertical angle measurement respectively.

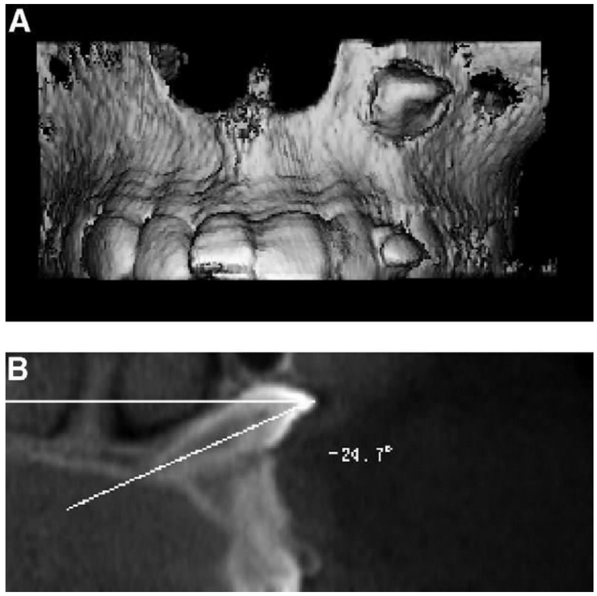


Fig. 5. (**A**) & (**B**) shows tooth 6 (Horizontal orientation) in trans-axial with apical curvature 1/3 of canine.

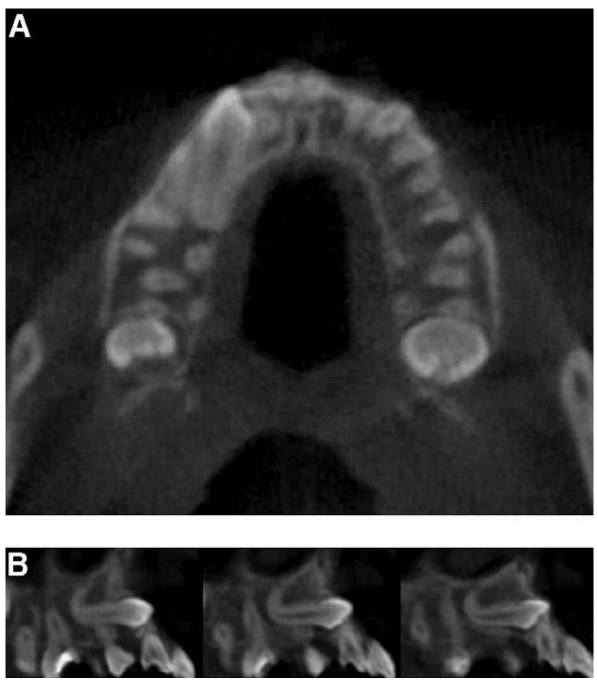


Fig. 6. A, location of tooth 11 (inverted) in 3-D view at anterior maxillary sinus wall. **B,** Supra-apical region, shows canine (inverted) in trans-axial view 12th tooth. Note 24.70° angle (vertical) between occlusal plane and long-axis of canine.

Angle variation shows 199.90° - 101.40° of IMCs (Horizontal angle) and 75.01° – 77.80° (vertical inclination). MLI as well as MPI angles (horizontal) were larger but distances smaller than control group showing mesial projection of crowns impacts with relatively closer cusp tip to midline comparing normal canines. Angle (horizontal and vertical) was lower in distal impactions in normal canine comparing control group (Table II).

Table – II: Horizontal and Vertical Angles

Impaction	No of Cases	Horizontal Angle		Horizontal Distances		Vertical angles	
		Mean	±SD	Mean	±SD	Mean	±SD
M-L-I	67	24.6	18.9	6.5	4	30.5	12.4
M-P-I	74	54.7	15.4	3.8	2.4	43.5	13.1
In situ impaction	31	10.6	32.3	13.6	3.6	58.3	13.1
Distal impaction	12	-96.6	62.3	22.2	7.9	42.6	17.1
Horizontal impaction	18	22	30.7	8.4	6.1	4.8	5.7
Inverted impaction	8	-25.9	35.1	16.6	4.7	-44.7	22.9
Control	30	-24.1	9.5	18.4	1.6	64.8	5

Table III contains detail of 120 ICs distributed as vertical zone. A huge difference was revealed in MPI and MLI through Chi-square test (_2.0_12.20; P_ 0.0160). Former vertical zones were in apical & middle 1/3 whereas latter were in middle & cervical 1/3.

Out of 206, resorbed incisors were resulted as 56 (27.20%) (Table IV). Out of 161, 53 laterals with and three out of forty-five lateral were resorbed without contact of canine. Resorption and contact having significant correlation (_2.0_12.30; P_0.0010). Central incisors resorption rate was 23.40% (49/209: one missing). Centrals with and without canine contact that resorbed were 46/78 and 3/131 respectively showing correlation of resorption and contact as (_2.0_87.50; P_0.0010). Total resorptions as mild, moderate and severe were 49,33, and 23 respectively (Fig. 1, D). Root resorption on lateral, central and both incisor was recorded as 36, 29, and 20 ICs respectively. Therefore, 210 ICs and resorption were associated as 40.50% (85). A number of sixty-five or 86.70% IR were found in 75 ICs located mesially in central, 42.001% (34) resorbed out of eighty-one ICs at lateral incisor region (_2.0_87.50; P_0.0010). Out of thirty-five ICs, 6 IRs were found in mesial-distally in situ.

Table III. Two hundred and Ten ICs of cusp tips' vertical zone distribution

Impaction	Supra-apical	Apical 1/3	Middle 1/3	Cervcal 1/3	Coronal
M-L-I	4	27	18	14	4
M-P-I	1	11	37	23	2
In situ impaction	0	2	11	18	0
Distal impaction	1	6	1	3	1
Horizontal impaction	6	10	2	0	0
Inverted Impaction	8	0	0	0	0
Total	**20**	**56**	**69**	**58**	**7**

Table IV. Incisors and ICs contact relation and Central/lateral IR distribution

Resorption Type	Lateral incisor (4 missing)		Central incisor (1 missing)		Total
	No touch	Touch	No Touch	Touch	
No	42	108	128	32	310
Mild	1	31	0	17	49
Moderate	1	12	3	17	33
Severe	1	10	0	12	23
Total	**45**	**161**	**131**	**78**	**415**

Only twenty-seven follicles were more than three millimeters out of 210 ICs with 4.601_1.01 millimeter of mean size, ranging 3.20-6.70 millimeter.

DISCUSSION:

IMCs vary in a range of 0.90%-3.01% with more tendency in women. Palatal impaction occurs two to three times more than labial in European subjects [3]. However, Asian patients have mid-alveolus/labial. Palatal impaction reported for Asian-Ratio-European is 1:5 [4]. In our research, ICs buccolingual position were 45.20%, 40.50% and 14.30% as labial, palatal and mid-alveolus respectively with Peck et al findings. Linear and angular measurements show great variations in IMC with an uncommon impaction mode. Palatal, buccal and labial descriptions are simple and cannot describe complex impactions comprehensively [5].

Our study summarizes six variations in impactions providing convenience in description of complex ICs location [6]. A percentage of 67.10 was represented by MPI and MLI being commonly used and mentioned in literature. Yet horizontal, inverted and distal impactions could be found scarcely in literature [7]. ICs spatial variations were depicted in three planes through linear and angular measurements. Also, these measurements and variations made 3-D relation of dental arch and relative impactions possible [8]. Experiences of author provided reference lines and occlusal plane which statistically proved reliable. The resulted lateral resorption percentages were comparable with Ericson and Kurol CT study (38.01%) of 156 ectopically IMCs but lower than Walker et al 66.701% [9]. Contrastingly, the higher central resorption percentage comparing Walker et al. and Ericson and Kurol has possible reason of different sample selection and CT images reading expertise. Therefore, IR must be predicted in ICs patients. The follicles size range indicates cystic degeneration propensity. Hence, the use of CBCT is our recommendation for ICs [10].

Root resorption mechanism being not clear, authors insists on exerting physical pressure because of displacement of MC. Present study supports this theory through its findings. This study shows significant correlation of IR with contact between ICs and incisors [11]. Also, the rate of IR influenced by location of mesial-canine shows that higher rate of resorption is related to position of medial-canine. Previous studies show same findings [12].

Results of treatment of IMCs depend on many variables like subject health, age, impaction type, crowding and spacing, cystic degeneration and teeth resorption. Alternative treatments include surgical exposure, auto-transplant, interceptive treatment, orthodontic alignment, or ICs extraction [13]. Extracting deciduous canines was recommended by Ericson and Kurol for ten to thirteen years' age, to correct palatal ICs. Patients may be refusing further treatment if deciduous canine is taken out [14]. Inverted and horizontal impactions means eruption path is severely abnormal (vertically) which makes canine extraction most desirable or it is left in situ. Orthodontic alignment and surgical exposure are alternative to interceptive treatment, if it is inappropriate to treat MPI and MLI.

CONCLUSION:

Conclusively, IMCs position varied a lot in position and inclination (vertical and horizontal). Palatal, buccal-labial, and central alveolus were recorded as 40.50%, 45.20%, and 14.30% respectively. Six variations in impactions through CBCT were summarized. MPI and MLI are displaced mesially with 67.10% of sample size. Impactions of in situ are centered in region on canine mesial-distally. Inverted, distal and horizontal impactions are mentioned scarcely in literature. IR in central and lateral incisors is present in 23.40% and 27.20% respectively. Due to close contact of incisors with canine, resorptions mostly occurred.

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