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Research Article

THREE DIMENSIONAL EVALUATION OF MANDIBULAR CANAL WITH IMPACTED MANDIBULAR THIRD MOLARS USING CONE BEAM COMPUTED TOMOGRAPHY

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A R T I C L E I N F O

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A B S T R A C T

Background and Objectives: The present study was designed to evaluate, the accurate relationship of the impacted third molar to the mandibular canal using cone beam computed tomography and its distance from cortical plates with its variation in relation to age, gender, side and angulation.
Materials and Methods: Three thirty four samples of cone beam computed tomography were identified. They were segregated according to different criterias say age, gender, side and angulation. The distance from the impacted tooth to the centre of mandibular third molar was measured. Also the distance between buccal and lingual cortical plates to the centre of the canal was measured. All the measurements were made with 3D CS software. Their variations with different criterias was identified.
Results: Statistical analysis was performed by using Karl Pearson correlation coefficient tests. The canal was most closely placed in case of females compared to males with respect to impacted tooth. Also the distance between the canal and tooth was less on the left side compared to the right side. There was no variation of the canal with age. But for angulation the distance was found to be more with horizontal and mesio angular impactions
Conclusion: The results of the present study shows that cone beam computed tomography is the best diagnostic tool to identify and locate the inferior alveolar canal in the mandible. The inferior alveolar canal has got a specific pattern of distribution which varies with side, age gender and angulations of impaction.

INTRODUCTION

Injuries to inferior alveolar nerve has been reported most often in third molar surgeries like impaction, reduction of fracture, implant placement, orthognathic surgeries etc. The evident variation of anatomical position or course of the inferior alveolar nerve in each patient has made it difficult to establish a proper anatomy of inferior alveolar nerve canal. Hence a detailed investigation of the course of the inferior alveolar canal is mandatory prior to treatment procedures.[1]

A better understanding of the intrabony anatomy of the inferior alveolar nerve and its relation with impacted third molar might avoid any risks or injuries encountered during impaction surgeries. Cadaver studies cannot be used as a reference because of the use of aged and diseased cadavers. Skull studies make use of irrelevant anatomical landmarks and may often include edentulous subjects. Computed tomography and two dimensional imaging are of limited diagnostic values.[3, 4]

The proximity of inferior alveolar nerve canal to the third molar should be assessed preoperatively to avoid its injury.

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Several signs are noticed in the radiograph in case of canal proximity such as darkening of roots, narrowing of the root, deviation of the canal and interruption of cortical lines.[5]About 0.5 to 0.8 percentage of an inferior alveolar nerve injury during an oral and maxillofacial procedure have been reported so far. Hence it is better to preoperatively evaluate the mandibular canal proximity to third molar before any surgical procedure.

Although radiographic investigations like orthopantamogram has limited applications, signs like interruptions of cortical line, a slight deviation in the course of mandibular canal, apex of the root getting narrowed and possible darkening of the root apex give an account on the proximity of canal on root apex.

Studies investigating the course of mandibular canal are less. A study stated that mandibular canal is traversing lingual second and third molar roots, also adjacent to the first molar roots and lateral to premolar roots[9]. Another study advocated three different types of mandibular canal according to configuration. They are a progressive curve rising type from anterior to posterior, a steep ascending type from anterior to posterior and also a catenary like canal.[9]Although the proximity of mandibular canal has less incidence, its complication can often be more serious indicating a more

precise investigation method. Cone beam computed tomography is an advanced imaging technique which has helped in improving diagnosis and treatment planning. CBCT gives a three dimensional visualization of vital structures. Its radiation dose is found to be lesser than other radiographic modalities. CBCT provides a good detail about the soft and hard tissue surrounding the third molar teeth and the amount of bone removal prior to the procedure.[10]

The images obtained through CBCT is reconstructed in many planes say axial, coronal, sagittal and also in cross sectional and panoramic views. CBCT can be considered as an ideal imaging modality for maxillofacial diagnosis.

Aims and Objectives

Aim of study

Aim: To evaluate the position and orientation of the mandibular canal with impacted mandibular third molars three dimensionally using Cone Beam CT.

Objectives of the study

1. To evaluate the distance from the centre of the mandibular canal to a point on the impacted mandibular third molar which is closest to the mandibular canal.
2. To evaluate the distance from the centre of the mandibular canal to the buccal and lingual cortical plates in cross section showing the mandibular canal and the most closest point on the impacted mandibular third molar.

Review of Literature

A study evaluated the preoperative application of cone beam computed tomography in imaging of minor oral surgical procedure. About 38 patient underwent the study and was prone to CBCT scan. The images done had a clear demarcation of anatomical structures along with the lesion. At the end of the study the author concluded that CBCT imaging is superior to any other imaging modalities in imaging in minor oral surgery.[21]

A prospective study was conducted to compare with panoramic imaging and volumetric computed tomography. Both panoramic and VCT were done for 10 third molar impaction cases. 3D reconstruction of both panoramic and paraxial views were done. The panoramic imaging provideda better quality image as compared to VCT. But the spatial relationship of the structures were better marked in VCT. Throughout his studies the author showed that CT has been widely used in diagnosis in dental imaging.[23]

A study was conducted compared the prospective radiographic findings with surgical findings after removal of third molar. Radiograph was revised and surgery was done. After surgery the morphology of tooth and its relation to inferior alveolar nerve was recorded a total of 300 radiographs were done and in about 35 cases there was deflection of root apices and roots were grooved. Post surgically none of the patient reported with persistent paresthesia except for one case where lingual flap was reflected.[17]

A study compared the reliability of cone beam computed tomography imaging in impaction surgeries with that of panoramic and cephalograms. The included patients were subjected topanoramic imaging followed by posterior anterior cephalogram and followed by a CBCT scan. A scoring criteria from 1 to 5 were given for each technique of radiography. In the study the CBCT images showed better landmarks horizontally as compared with panoramic imaging and cephalograms. At the end of the study it was concluded that CBCT is more superior to panoramic imaging and cephalograms for diagnosis of impactions.[20]

A CBCT study was conducted to correlate some radiographic findings and the risk of nerve injury due to nerve proximity. The radiographic characteristics considered were the darkening of root, loss of radiopaque line and deviation of the canal. This was a prospective study and 50 cases were evaluated. Assessing all the characteristics, it was concluded after the study that loss of radiopaque line and deviation of inferior alveolar canal is an indication of nerve injury.[13]

A study was conducted to assess the relationship of inferior alveolar canal and roots of wisdom teeth with CBCT as a diagnostic tool. On panoramic radiograph the relationship between the lower third molar and mandibular canal was classified into three categories according to tip of the tooth as apex at upper half of the canal, lower half of the canal and inferior wall of the canal. In CBCT the relationship was categorized as buccal, lingual, inferior and between the roots. The author in this study concluded that CBCT is more accurate in determining the presence or absence of cortical bone separating the nerve and the root.[15]

A study was conducted to evaluate the correlation of darkening of third molar root with CBCT imaging. 253 impactions from 152 patients were evaluated. Two observers independently evaluated the samples. On panoramic imaging the presence of darkening of root was taken as criteria. But on CBCT imaging two criteria were evaluated say grooving of root or perforation or thinning of cortex by root or mandibular canals. After evaluation it was concluded that the panoramic findings of darkening of root was more coinciding more with perforation of cortex rather than grooving of root in CBCT.[16]

A study was conducted to assess the ability of dental CBCT in predicting the exposure of inferior alveolar nerve and its injury. In this retrospective study about 53 impactions in 47 patients were evaluated. The cases were divided into 2 categories say case with contact and without contact of inferior alveolar nerve with impacted molar root apices. In this study it was concluded that if there is contact between these two structures indicated a high risk of nerve injury due to nerve exposure during the surgery.[12]

A study conducted evaluated the reliability of CBCT imaging in third molar impaction surgeries. The number of patients included in the study were 42. In all these cases there was overlapping between tooth root and inferior alveolar canal. But CBCT matched the inter observer and intra observer reading. In his study the author himself concluded that CBCT is a reliable technique in third molar impaction cases. A better idea about the course of inferior alveolar canal can be obtained from CBCT imaging.[22]

A prospective study was conducted to compare with CBCT imaging and panoramic imaging to assess the relationship between impacted mandibular third molar and inferior alveolar nerve. In panoramic imaging there was deviation of nerve and darkening of roots were noted. The same samples when underwent CBCT imaging showed contact of tooth with nerve.

After the study it was concluded that darkening of roots and deviation of roots in panoramic imaging indicated an added risk of nerve injury.[25] A study was undertaken incorporating cone beam computed tomography to measure the proximity of root apex of mandibular second premolar, first molar and second molar to mandibular canal. 139 patients were evaluated. It concluded that the root apices of the second molar are comparatively closer to mandibular canal when compared with other teeth in the study.[3]

A study investigated need for threedimensional oral imaging for impacted third molar removal. The study was a retrospective one. After presence of darkening of root apex in radiograph, the cases were repeated with CBCT imaging to check the spatial relation of the tooth, type of angulation, root configuration and maturation. It was concluded that 3D imaging was the best diagnostic technique for investigation of mandibular third molar showing close proximity to root.[18]

A study evaluated the position of inferior alveolar nerve in a population of 20 patients of south India. Patients between the age group of 20-29 years of age & with all teeth present were evaluated using cone beam computed tomography. The variables evaluated were linear distance between the buccal and lingual aspect of the inferior alveolar canal, Buccal and lingual cortical thickness, inferior alveolar nerve canal diameter and the superior aspect of inferior alveolar nerve canal from the periapex of the first and second mandibular molar. In the study the mean lingual cortical thickness was found to be 1.68 mm at the 1st molar and 1.44 at the 2nd molar level. The authors opined that that the parameters taken into consideration will influence the prognosis of surgery.[1]

A study evaluated the variations of inferior alveolar nerve position according to age and gender. Cone beam computed tomography images of 100 females and 100 males aged between 15-65 were evaluated. Subjects were grouped according to the age and 7 anatomical measurements were taken into consideration. The study concluded that the position of the inferior alveolar nerve is closer to the root apex of the tooth in females.[2]

A study was conducted to determine the diagnostic accuracy of panoramic imaging and CBCT in predicting nerve injury during impactions. In this prospective study after preoperative imaging with panoramic imaging and CBCT the impactions were carried out. The patient was post operatively evaluated for the temporary and permanent inferior alveolar nerve injury. After a recall of 3months and 6 months clinical and radiographic outcomes were correlated. After the study it was concluded that there is no significant panoramic and cone beam CT in predicting the outcome risk of nerve injury.[14]

A study evaluated the reliability of four panoramic signs in predicting the absence of corticalisation between mandibular canal and impacted third molar on CBCT images. The sample consisted of 142 impacted third molar with characteristics like darkening of roots, diversion of mandibular canal, narrowing of mandibular canal and interruption of white cortical line. Darkening of roots and interruption of white cortical line indicated absence of corticalization in CBCT imaging.[24]

In a study the distance between the inferior alveolar canal and the root apex of mandibular first and second molar and mandibular second premolar were evaluated using CBCT imaging. CBCT images of 40 male and 40 females were evaluated. The patients examined were in between the age of 20-40, without any mandibular pathologies, had all the teeth present except third molars, and malocclusions that ruled out alteration in the position of the tooth. After the study it was concluded that irrespective of the age the inferior alveolar canal was close in females.[8]A study was conducted to evaluate the relation between third molar and inferior alveolar canal. The study included 87 third molars. The study samples were selected after two dimensional imaging for which the samples showed super imposition of canal. After that cone beam computed tomography was adviced. In almost 91% of cases the canal and roots had a close proximity. The study concluded CBCT as one of the best diagnostic tool for tooth subjected for superimposed canal.[26]

A study conducted evaluated the risk factors associated with the injury to inferior alveolar and lingual nerves following third molar surgery. Patients are assessed with preoperative radiographs. After surgery the patients were examined for paresthesia after subsequent recall visits. After it was concluded that the injury to the nerve during surgery is largely dependent on the operator skill irrespective of the factors like nerve proximity.[19]

A study was conducted to compare the precision of orthopantomogram with computed cone beam tomography in respect to the proximity of mandibular canal with mandibular molar, characteristics like bifid dilacerating roots, presence of cortical lines narrowing were evaluated and assessed. 29 patients with 43 class c impacted mandibular molars were evaluated. After the study it was concluded that CBCT can give a precise information regarding the course of mandibular canal. Although panoramic imaging can be also used as a diagnostic aid to predict the risk of nerve injury.[6]

A study with cone beam computed tomography evaluated the location of mandibular canal and thickness of the occlusal cortical bone at the dental implant site in the lower second premolar and lower first molar. The distance from the mandibular canal to upper border of the mandible, lower border of the mandible, buccal border of the mandible, lingual border of the mandible, & thickness of the cortical bone at the occlusal side was measured. The study concluded, primary stability of implant thickness of the second molar was lesser than that of first molar.[5] A study was conducted to evaluate the buccolingual course of inferior alveolar nerve. About three hundred hemimandibular images were randomly evaluated using CBCT. The measurements were done in about 9 aspects. All measurements were recorded from posterior mandibular premolars and molars. At the end of the study it was concluded that there is significant variation in the course of inferior alveolar canal with variation of position of mental foramen.[11]

A study was conducted to identify the age changes of the jaw and soft tissue profile in the human face. After the study it was concluded that the childs face undergoes different transformations and age changes as age progresses.[27]A study was conducted to assess the relationship between inferior alveolar nerve and roots of mandibular wisdom tooth using CBCT. After the study it was concluded that cone beam computed tomography can provide useful information tool to determine the relation of the inferior alveolar canal to

mandibular third molar teeth. It can be used as risk assessment tool for inferior alveolar nerve injury.[31]

A study was conducted to check the reliability of panoramic imaging in predicting the proximity of the mandibular canal with mandibular impacted molar. 96 patients with 132 impactions were examined with both panoramic and computed cone beam tomography imaging. The proximity of the alveolar canal with the mandibular molar was evaluated three dimensionally, coronally, axially and cross sectionally. In panoramic imaging, the proximity of the canal was discussed with the presence or absence of interruption of the mandibular canal walls, dilacerating roots, diversion of the mandibular canal and root dilaceration. After the study it was concluded that panoramic imaging can give information regarding the nerve proximity to mandibular molars.[7]

In a study conducted the measurement of lingual plate thickness, lingual cortical plate distance from impacted lower third molar was assessed using CBCT.251 impactions were assessed randomly in this study. After that the impactions were sorted into mesioangular, horizontal, vertical and distoangular excluding the other classification of winter's type. The distance from root apex to lingual cortical plates were measured. Also the distance from the lingual point on the apical half of the root to lingual cortical plates is measured. The average distance between root and lingual cortical plates were found to be 3.38 mm.[10]

A study was conducted to identify the difference of mandibular ramus height in relation to different gender. Radiographic samples of 60 males and 60 females were evaluated view 3.0 software. At the end of the study it was concluded that the ramus height ramus width and condylar height were more for males. Mandibular ramus height can be used as a tool for sex determination.[28] A study probably the first one on an Iranian population was conducted to learn the course of inferior alveolar nerve canal. 920 CBCT images were evaluated. The inclusion criteria were the presence of both premolars and molars. The exclusion criteria were the presence of any pathologies and presence of any fracture, supernumerary tooth or impaction in the region of interest. 150 CBCT volumes met the inclusion criteria. CBCT were taken with Nerve TOM VGI Scanner. After the study it was concluded that the course of inferior alveolar nerve canal were not influenced by either age or gender. CBCT was found to be a precise method for determining the course of inferior alveolar canal.[9]

A study investigated the rules for the placement of monocortical screws in the mandible on 35 patients. The distance from the alveolar crest to superior border of the mandible was determined using cone beam computed tomography and the shortest distance of buccal and lingual cortex to the mandibular canal in between the premolar and molar area were evaluated. The study concluded, length for safe orthodontic anchorage was about 6mm.[4] A study was conducted to identify the age and gender correlation of the ramus height, gonial angle and bigonial width. From panoramic radiographs. The study evaluated 2699 panoramic radiographs. At the end of the study it was concluded that the gonial angle was more for females. Ramus height and bigonial width was more for males.[29]

MATERIALS AND METHODS

Study design: A retrospective evaluative study using patient pre-operative CBCT records.

Study setting: ORAL –D diagnostic center, Bangalore.

Study duration: 18 months.

Source of data

Materials

- Dental CBCT images
- CS 3D software

Methods of Collection of Data

Digital radiographic data of patients from the archives of ORAL- D diagnostic center, Bangalore.

Inclusion Criteria

1. CBCT images of patients from 20-45 years of age.
2. CBCT images of patients with impacted third molars.

Exclusion Criteria

CBCT images of patients with any pathology or developmental disturbance that may influence the course and position of the mandibular canal.

Sample Size

1. 334 CBCT radiographic samples from ORAL D diagnostic center, Bangalore.
2. Personal identity of the patient will not be revealed throughout the study.

Sample size calculation

To determine the sample size for **"**Three Dimensional Evaluation Of Mandibular Canal With Impacted Mandibular Third Molars Using Cone Beam Computed Tomography**"** we use the formula of "Sample size calculation for difference between means".

Formula is

Based on the published literature, the position of mandibular canal will be estimated.

Assuming power is 90%.

$n = N / (1+Ne^2)$

N = 2000 (total number of radiographic sample available in an year)

e = 0.05 (error tolerance)

n = 2000 / (1+2000X 0.0025)

n = 334

The required sample size is 334

METHODOLOGY

CBCT images of mandible were obtained from ORAL –D diagnostic center in Bangalore. CBCT images which meet the inclusion criteria were selected for the study.

The age of the patients selected were from 20-45 years. Personal identity of the patients were not revealed during or after the study.

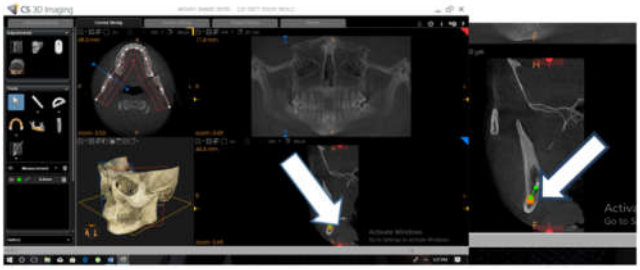
The CBCT images obtained were be evaluated for different parameters. The parameters evaluated in the study were

1. The distance from the centre of the mandibular canal to a point on the impacted mandibular third molar teeth which is closest to mandibular canal.
2. The distance from the centre of the mandibular canal to the buccal and lingual cortical plates in a cross section showing the mandibular canal and the closest point on the impacted mandibular third molar with the mandibular canal.

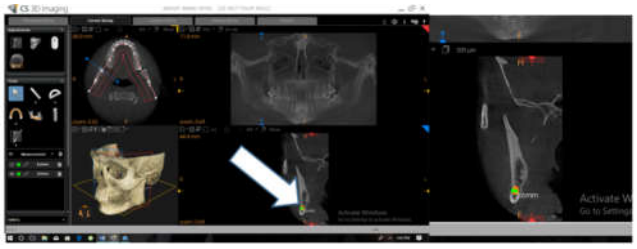
The CBCT images were segregated accordingly based on angulation of impacted teeth. The variation of distance of mandibular canal from the root apex according to the angulation of the impacted tooth were be evaluated.

The parameters were evaluated using 3d CS software. In this each of the distances mentioned above were measured using the software with the help of a trained professional. All the distance were measured using coronal, axial and sagittal sections After evaluation of the distance from the CBCT images, a detailed report was obtained for each image. The report was used for statistical analysis. The softcopy of each of the radiographic images were collected and saved and compiled. The data obtained weres subjected to statistical analysis.

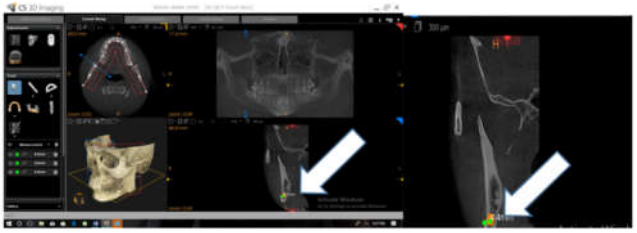
Distance from The Closest Point on the Tooth to Centre of The Mandibular Canal



Distance from the Centre of the Canal to Inner Buccal Cortical plates



Distance from the Centre of the Canal to Outer Buccal Cortical Plates



Distance from the Centre of the canal To Inner Lingual cortical Plates

Distance from the centre of the Canal To Outer Lingual Cortical Plates

RESULTS

Statistics and Results

Table 1

	Mean	Standard deviation
A	4.2314	1.50937
B	2.4804	1.05422
C	3.7871	1.32363
D	1.9740	0.95864
E	3.2701	1.14491
Age (in years)	25.7934	6.38804
Angulation (degree)	40.4775	25.91909

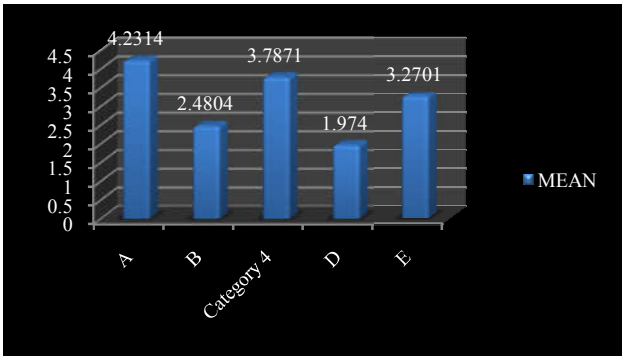
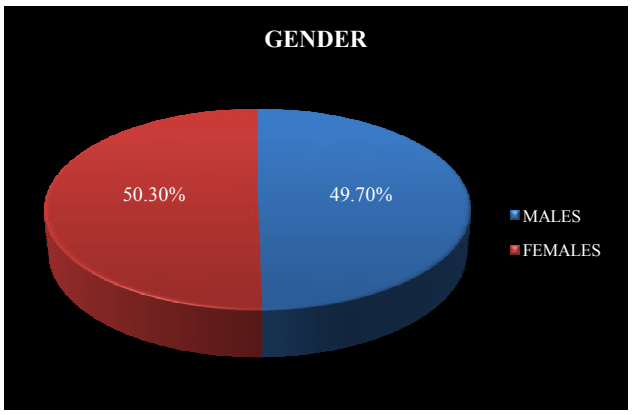


Table 2

		Frequency (%)
Gender	M	166 (49.7)
	F	168 (50.3)
	Total	334 (100)
Side	R	180 (53.9)
	L	154 (46.1)
	Total	334 (100)



According to the present study conducted 334 CBCT records were subjected for evaluation. After the study the mean findings for each of the parameters were tabulated in table 2. The frequency of side of the subjected tooth and the gender of the included subjects are included in the table 3.

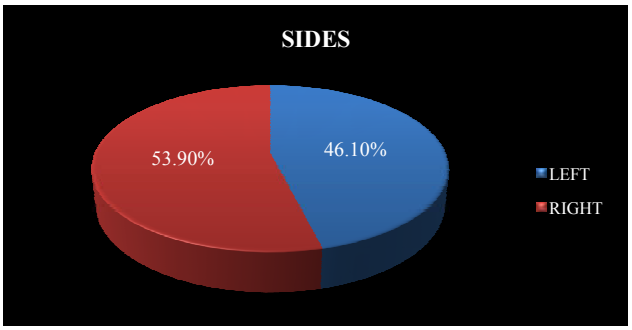
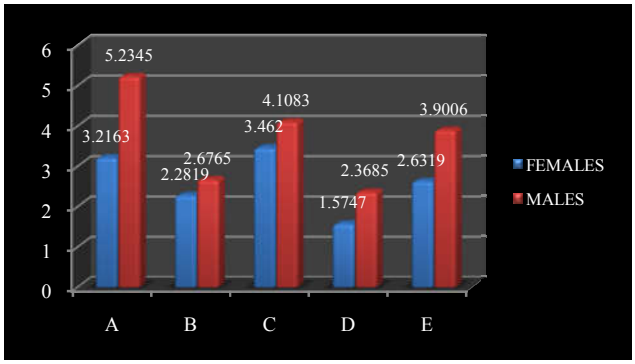


Table 3 Comparison between males and females

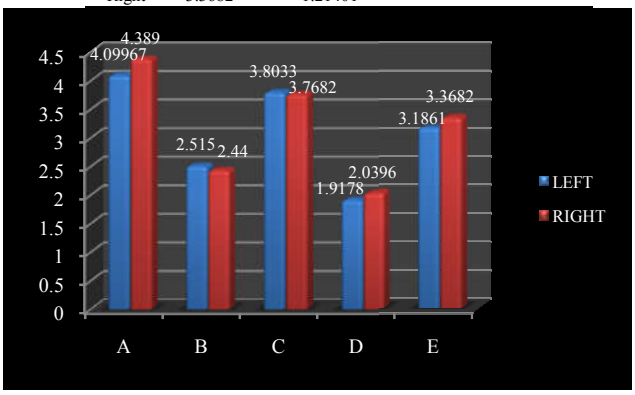
		Mean	Standard deviation	T	Sig.
A	Females	3.2163	.55610	-16.426	0.000 (H.S)
	Males	5.2345	1.48344		
B	Females	2.2819	.72139	-3.477	0.000 (H.S)
	Males	2.6765	1.27439		
C	Females	3.4620	.61865	-4.594	0.000 (H.S)
	Males	4.1083	1.70485		
D	Females	1.5747	0.38260	-8.302	0.000 (H.S)
	Males	2.3685	1.17168		
E	Females	2.6319	0.39727	-12.153	0.000 (H.S)
	Males	3.9006	1.28573		



According to the study the parameters were evaluated with respect to each geneder. According to the study the mean value of the distance from the tooth to the centre of the inferior alveolar canal (A) was found to be 3.2163 mm in females and 5.2345 mm in males. The distance from the cenre of the canal to inner buccal plate (B) was 2.2819 and 2.6765 mm in females and males respectievely. The distance from the centre of the canal to outer buccal plates (C) was found to be 3.4620mm in females and 4.1083mm in males respectievely. Distance between the centre of the canal to inner lingual plates (D) was found to be 1.5747mm in females and 2.3685mm in males. Distance from the canal to outer lingual plates (E) was found to be 2.6319mm and 3.9006mm in females and males respectievely. All the findings were found to be highly significant.

Table 4 Comparison between left and right

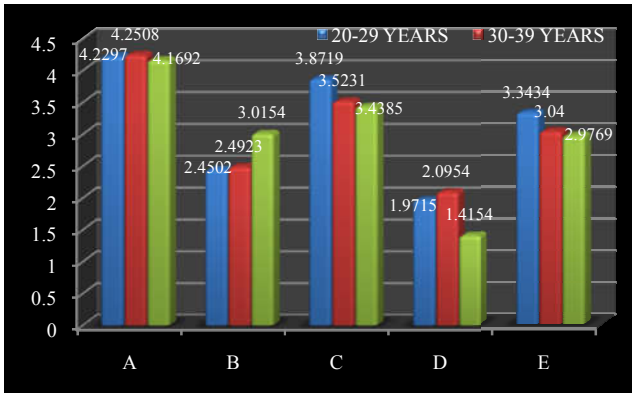
		Mean	Standard deviation	T	Sig.
A	Left	4.0967	1.40684	-1.770	**0.048 (S)**
	Right	4.3890	1.61138		
B	Left	2.5150	1.00554	0.648	0.332 (N.S)
	Right	2.4400	1.11035		
C	Left	3.8033	1.08457	0.242	0.159 (N.S)
	Right	3.7682	1.56087		
D	Left	1.9178	.89143	-1.158	**0.032 (S)**
	Right	2.0396	1.03073		
E	Left	3.1861	1.07863	-1.451	0.148 (N.S)
	Right	3.3682	1.21401		



The study also plotted the diversion each parameters with respect to both sides. The frequency distribution of subjects with left side and right side were 46.1% with left side 53.9% on the right side. The mean value of the parameter A on the left side was 4.0967 and 4.3890 on the left side and right side respectievely. The standard deviation was 1.4 on the left side and 1.6 on the right side. Mean value of parameter B was 2.5150 and 2.4400 on the left and right side respectievely. The standard deviation was 1.00 and 1.11 in left and right side respectievely. Mean value of parameter C was 3.8033mm and 3.7682mm in left and right side respectievely. The parameter D had its value as 1.9178 and 2.0396mm on left side and right side respectievely. The parameter E had its value as 3.1861mm and 3.3682mm respectievely on left side and right side.

Table 5 Comparison between A,B,C,D, E in different age groups.

		N	Mean	Standard deviation	F	Sig.
A	20-29 years	256	4.2297	1.58490	2.016	0.032 (S)
	30-39 years	65	4.2508	1.25451		
	40-49 years	13	4.1692	1.20096		
B	20-29 years	256	2.4502	1.09308	1.791	0.016 (S)
	30-39 years	65	2.4923	.88817		
	40-49 years	13	3.0154	.95555		
C	20-29 years	256	3.8719	1.39354	2.287	0.010 (S)
	30-39 years	65	3.5231	1.03784		
	40-49 years	13	3.4385	.97172		
D	20-29 years	256	1.9715	1.01835	2.758	0.045 (S)
	30-39 years	65	2.0954	.73430		
	40-49 years	13	1.4154	.41402		
E	20-29 years	256	3.3434	1.20971	2.280	0.011 (S)
	30-39 years	65	3.0400	.91289		
	40-49 years	13	2.9769	.58188		



In the present study the variation of each parameters with respect to different age groups were plotted. The study subjects were divided into three different age groups say from 20-29,30-39 and from 40-49. All the results were tabulated in TABLE 6 and a graph was plotted relating to the results. The variation in each parameters and the age changes were evaluated and plotted down.

Table 6

			Mean Difference	Standard Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
A	20 – 29 years	30-39 years	-.02108	.21026	.994 (N.S)	-.5161	.4739
		40 – 49 years	.06046	.43039	.012 (S)	-.9528	1.0737
	30-39 years	40-49 years	.08154	.45994	.983 (N.S)	-1.0013	1.1644
B	20 – 29 years	30-39 years	-.04207	.14608	.955 (N.S)	-.3860	.3018
		40 – 49 years	-.56515	.29901	.014 (S)	-1.2691	.1388
	30-39 years	40-49 years	-.52308	.31954	.232 (N.S)	-1.2754	.2292
C	20 – 29 years	30-39 years	.34880	.18313	.139 (N.S)	-.0824	.7800
		40 – 49 years	.43341	.37487	.048 (S)	-.4491	1.3160
	30-39 years	40-49 years	.08462	.40060	.976 (N.S)	-.8585	1.0278
D	20 – 29 years	30-39 years	-.12390	.13245	.618 (N.S)	-.4357	.1879
		40 – 49 years	.55610	.27112	.012 (S)	-.0822	1.1944
	30-39 years	40-49 years	.68000	.28973	.045 (S)	-.0021	1.3621
E	20 – 29 years	30-39 years	.30336	.15841	.136 (N.S)	-.0696	.6763
		40 – 49 years	.36644	.32426	.049(S)	-.3970	1.1298
	30-39 years	40-49 years	.06308	.34652	.982 (N.S)	-.7527	.8789

Table 7 Comparison of A.B.C.D.E between different angulation

		N	Mean	Standard deviation	F	Sig.
A	Horizontal	33	4.3333	1.56977	0.207	0.891 (N.S)
	Mesioangular	274	4.2320	1.24020		
	Vertical	25	4.2245	1.53285		
	Distoangular	2	3.5000	.00000		
B	Horizontal	33	2.7333	1.43215	4.228	0.006 (H.S)
	Mesioangular	274	2.7600	.74833		
	Vertical	25	2.4218	1.01982		
	Distoangular	2	2.8500	1.34350		
C	Horizontal	33	4.3939	1.98162	2.801	0.040 (S)
	Mesioangular	274	3.8880	.81768		
	Vertical	25	3.7029	1.24973		
	Distoangular	2	4.0500	.91924		
D	Horizontal	33	2.4576	1.08341	3.937	0.009 (H.S)
	Mesioangular	274	2.1560	1.06813		
	Vertical	25	1.9033	.91872		
	Distoangular	2	1.4000	.28284		
E	Horizontal	33	3.7727	1.41891	2.753	0.043 (S)
	Mesioangular	274	3.4320	1.28476		
	Vertical	25	3.1971	1.08550		
	Distoangular	2	2.9500	.35355		

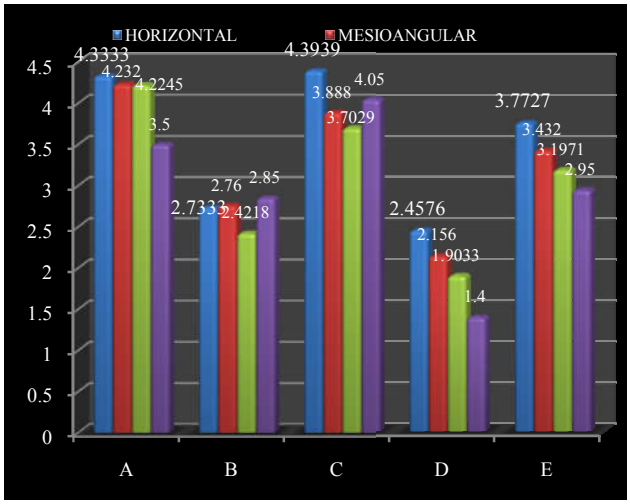


Table 8

			Mean difference	Standard error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
A	Horizontal	Mesioangular	.10133	.40164	.994 9(N.S)	-.9358	1.1384
		Vertical	.10888	.27912	.980 (N.S)	-.6119	.8296
		Distoangular	.83333	1.10310	.874 (N.S)	-2.0151	3.6817
	Mesioangular	Vertical	.00755	.31648	1.000 (N.S)	-.8097	.8247
		Distoangular	.73200	1.11314	.913 (N.S)	-2.1423	3.6063
	Vertical	Distoangular	.72445	1.07502	.907 (N.S)	-2.0514	3.5003
B	Horizontal	Mesioangular	-.02667	.27878	1.000 (N.S)	-.7465	.6932
		Vertical	.31158	.19374	.375 (N.S)	-.1887	.8118
		Distoangular	-.11667	.76566	.999 (N.S)	-2.0937	1.8604
	Mesioangular	Vertical	.33825	.21967	.415 (N.S)	-.2290	.9055
		Distoangular	-.09000	.77263	.019 (S)	-2.0851	1.9051
	Vertical	Distoangular	-.42825	.74617	.940 (N.S)	-2.3550	1.4985
C	Horizontal	Mesioangular	.50594	.34814	.467 (N.S)	-.3930	1.4049
		Vertical	.69102*	.24194	.023 (S)	.0663	1.3158
		Distoangular	.34394	.95617	.984 (N.S)	-2.1250	2.8129
	Mesioangular	Vertical	.18508	.27432	.907 (N.S)	-.5233	.8934
		Distoangular	-.16200	.96487	.998 (N.S)	-2.6535	2.3295
	Vertical	Distoangular	-.34708	.93183	.982 (N.S)	-2.7532	2.0591
D	Horizontal	Mesioangular	.30158	.25088	.626 (N.S)	-.3462	.9494
		Vertical	.55429*	.17435	.009 (H.S)	.1041	1.0045
		Distoangular	1.05758	.68904	.418 (N.S)	-.7217	2.8368
	Mesioangular	Vertical	.25272	.19769	.577 (N.S)	-.2577	.7632
		Distoangular	.75600	.69531	.698 (N.S)	-1.0394	2.5514
	Vertical	Distoangular	.50328	.67150	.877 (N.S)	-1.2307	2.2372
E	Horizontal	Mesioangular	.34073	.30120	.670 (N.S)	-.4370	1.1185
		Vertical	.57565*	.20932	.032 (S)	.0352	1.1161
		Distoangular	.82273	.82724	.753 (N.S)	-1.3133	2.9588
	Mesioangular	Vertical	.23492	.23733	.755 (N.S)	-.3779	.8478
		Distoangular	.48200	.83477	.939 (N.S)	-1.6735	2.6375
	Vertical	Distoangular	.24708	.80618	.990 (N.S)	-1.8346	2.3288

Also the variation in the parameters with respect to different angulations were tabulated in a table table 8 and also their variations were plotted down. The results when plotted on the graph showed the distance between tooth and the canal to be more on the horizontal impaction followed by mesioangular, vertical and distoangular impactions. After that a pearsons correlation table was plotted between the parameters.

Table 9

		Pearson correlation	Sig.
Angulation	A	-0.035	0.522 (N.S)
	B	-0.013	0.816 (N.S)
	C	-0.143	0.009 (H.S)
	D	-0.106	0.053 (N.S)
	E	-0.113	0.040 (S)

This is for your understanding of pearson correlation in the above table.. 0.90 to 1 → very high positive/negative

correlation, 0.7 to 0.9 → high positive/negative correlation, 0.5 to 0.7 →moderate positive/negative correlation, 0.3 to 0.5 → low positive/negative correlation and 0.00 to 0.3 is negligible correlation.

Table 10

		Pearson correlation	Sig.
Age	A	0.072	0.072 (N.S)
	B	0.118	0.031 (S)
	C	-0.072	0.191 (N.S)
	D	0.048	0.380 (N.S)
	E	-0.044	0.426 (N.S)

This is for your understanding of pearson correlation in the above table.. 0.90 to 1 → very high positive/negative correlation, 0.7 to 0.9 → high positive/negative correlation, 0.5 to 0.7 →moderate positive/negative correlation, 0.3 to 0.5 → low positive/negative correlation and 0.00 to 0.3 is negligible correlation.

DISCUSSION

The inferior alveolar nerve, a terminal branch of mandibular division of trigeminal nerve has its origin from the mandibular canal. In the mandible it traverses in proximity with the tooth root either medially or laterally and exit out through the mental foramen. There is always a variation in the course of the nerve canal in each patient. Even though these variations exist, through various studies the course of the inferior alveolar canal have been generalised for diagnostic and therapeutic purposes. Often they can be seen in close proximity with impacted third molar. Mandibular third molar impactions are one of the most frequently encountered cases in oral and maxillofacial surgery. The incidence of inferior alveolar nerve injury during impaction procedures is 0.35% to 8.4% .[1]

In cases where root is indirect contact with nerve the incidence of inferior alveolar nerve injury is 30%.This is mainly due to:

1. Age of the patient
2. Surgical procedure
3. Depth of the impaction
4. Height of the mandible

Most commonly occurred complication with inferior alveolar injury is parasthaesia especially of the lips. In most cases the nerve will repair by itself. But a possibility of permanent paraesthesia cannot be ruled out.

These factors enmark the significance of a preoperative investigation of the nerve proximity in relation to the impacted third molar for better treatment planning and for an uneventful treatment outcome. Radiographic investigation is the most common technique used. Of them commonly employed preoperative investigative technique isperiapical radiographs ororthopantomogram.

Periapical radiograph is one of the basic radiographic diagnostic means employed in oral and maxillofacial surgery. They are often used as a radiographic means in diagnosis of impacted mandibular third molar. They can give some details regarding the nerve canal proximity with reference to certain radiographic signs

Orthopantamogram is one of the widely used technique for dental radiography. The main advantage of these techniques is that it is

1. Cost effective
2. Easy to perform
3. But they cannot always give a precise data accounting to the
4. Magnification
5. Superimposition
6. Distortion.

There are various radiographic signs which gives an indication of nerve proximity.

There are some radiographic signs which always predict the possibility of inferior alveolar nerve canal proximity with the mandibular third molar roots. These are as follows

- Darkening of the root
- Deflection of the roots
- Narrowing of the root
- Dark and bifid apex of the root
- Interruption of white lines of the canal
- Diversion of the inferior alveolar canal
- Narrowing of the inferior alveolar canal

Darkening of root: Roots in a radiographic image normally show the same density. There is no disturbances in the density of the root even if the mandibular canal overlaps the root. But when the root is impinged by the canal the density is altered and darkening of root is experienced. About 93.1% of the roots with nerve proximity shows the feature. This is mainly due to decreased amount of tooth structure or loss of cortical lining within the canal.

Deflection of root: Deflection of the root is mainly due to the roots pathway obstructed by the canal. As a result the root is deviated from its normal pathway. It is deviated buccaly, lingualy, mesialy or distally.

Narrowing of root: It indicates greater dimension of roots being involved by the canal or perforation of roots.

Interruption of white cortical lines: The white cortical lines are often seen as the walls surrounding the inferior alveolar canal. When the canal is in close proximity with the roots the continuity of the walls are disturbed. Either it will be superior or inferior wall or both of them gets involved.

Dark and bifid roots: These appear in the radiograph if inferior alveolar canal crosses the root apex.

Deflection of the canal: It is due to the compression of the roots to canal bundle so that the course of the nerve canal is deviated from its pathway. Another radiographic techniques is conventional CT. This technique had an advantage over the panoramic imaging that it gives a three dimensional relation between the roots and inferior alveolar nerve. The most common disadvantage of this technique is its high radiation exposure comparing to the panoramic radiography.

Cone beam computed tomography also known as denta scan is an advancement over the conventional CT in that it is able to produce three dimensional images with less radiation exposure. However its radiation exposure is far greater than the conventional panoramic imaging and the intra oral imaging. But taking into consideration the diagnostic details produced by the cone beam computed tomography in cases with nerve proximity, the radiation exposure factor is often ignored. However the radiation exposure of CBCT is

comparatively lesser than the conventional CT. the effective dose of various radiographic techniques are as follows

Radiographic source	Effective dose(lSv) ICRP 1990 ICRP2005
Cone beam computed tomography CBCT	7.2 – 435.5
Conventional computed tomography	1400 (max)
Conventional CT	1320 (mand)
Conventional Radiography	
Panoramic	6.3
Periapical	5
Maxillary occlusal	7

Operator should be aware of thebuccolingual course of the nerve prior to the surgery inorder to plan for the procedure. A knowledge about the buccolingual course of the nerve allows the operator to direct the elevators. Even though there is no direct relationship between the nerve and the root, there are chances of inferior alveolar nerve injury. During the procedure there is chance for the roots to go down and compress the inferior alveolar nerve. The CBCT allows the operator to select the approach for treatment.[26]

Height of the Mandible and Gender Variations

In the study the distance between the tooth and the canal was more in males. The average distance of canal from the tooth in males were 5.23mm and in females were 3.21mm. According to the present study the cortical bone thickness was found to be more in males than females.

There can be variations in the height of the mandible in male and female. The height of the mandible can influence the distance of the canal from the tooth. More the height of the mandible, more will be the distance of the canal from the tooth.

A study was conducted by *K.Samatha et.al* to determine the gender with the help of mandibular ramus using OPG. In his study the mean projective height of ramus was 62mm in male and 58 mm in female. A study was conducted to determine the age and gender correlation of gonial angle,ramus height and bigonial width by *Jodi leversha et.al*. He stated that the ramus height was comparitevely more for male. The mean ramus height of the males were 68.66mm and females were 62.86mm. [28]

Side of the Tooth Involved

In the present study the distance of canal from the tooth on the left side of the mandible was found less than the right side. This is because of the possible variation of the height of the ramus of the mandible on each sides. *Jodi Leversha et.al* in his study stated that the mandibular ramus height on the left side was lesser than that of right side irrespective of the gender. For males on the right side the mandibular ramus height was 69.98mm whereas on the left side it was 68.37mm. For females on the right side the mandibular ramus height was found to be 63mm and on the left side it was 62.72mm.[28]

Age Factor

In the study there was variation of distance between the canal and tooth in each age groups. We had divided the samples into different age groups such as 20-29,30-39,40-49. In all these age groups the canal position was showing no relative variation with respect to the age. However there was a decrease in distance of canal from the tooth in age group of 40-49 as compared to 30-39 age group. This could be due to age related changes which leads to bone resorption, decrease in bone density and leading to migration of the inferior alveolar canal towards the tooth. In age group of 30 -39 the distance between the tooth and the canal was more and found to be 4.25mm. This might be because the mandible attains its growth during this age group and the rate of growth being more than other two groups. Studies suggested that growth in mandible continues until third decades of life. Increase in the length of jaw were stated by *Sarnas* and *Solow* between 21 to 26 years of age. *Bishara et.al* advocated the same growth to take place till the fourth decade of life.[27]

In the present study irrespective of the side the distance of canal from the cortical plates on the lingual side was less than that of buccal cortical plates. But these difference were negligible. Thus it suggested that in most of the subjected cases the canal position is inferior. According to a study conducted by *Yabroudi* the position of the inferior alveolar canal with respect to the tooth was classified as buccal, lingual, inferior, and intermediate with incidence of buccal inferior, lingual and intermediate being 17.02%, 44.68%, 23.4% and 14.89% respectively.[31]

Angulation of the Tooth

The tooth - canal distance was more in the case of horizontally impacted tooth followed by mesioangular, vertical and distoangular impacted tooth. The mean canal tooth distance was more in the case of horizontal impacted tooth was found to be 4.33mm. In the case of mesioangular impactions it was found to be 4.23mm. For vertical and distoangular impactions it was found to be 4.22 and 3.5 mm. In horizontal and mesioangular impactions, the crown of the tooth gets embedded in the mandible and causes deflection of the canal away from the crowns. In thestudy many of the cases were class2, position B impactions where the crown gets totally embedded inside the cortical bone causing deflection of the canal. The deflection of canal is mainly because of the presence of surrounding follicular spaces from the tooth that the canal far apart from them.

A study was conducted to determine the follicular spaces surrounding the impacted molar using cone beam computed tomography. In the study it was found that the follicular space is more for the horizontally impacted and mesioangularly impacted tooth. Similarly the buccal cortical plates distance from the inferior alveolar canal was showing the same trend except for the distoangular impactions it was unexpectedly more. But the distance of the canal and lingual cortical plates were in a descending order of horizontal, mesioangular, vertical and distoangular.

Position and Spatial Relation

There is yet another criteria to classify impacted molars in relation to its position with respect to the adjacent teeth and also the spatial relation ship between the adjacent tooth and anterior border of ramus according to Pell and Gregory's classification.

According to Position

Position A: The highest point of the impacted tooth is in line with the occlusal surface of the adjacent tooth.
Position B: The highest point of the impacted tooth is below the occlusal surface but above the cervical region of the adjacent tooth.
Position C: The highest point of the impacted tooth is below the cervical level of the adjacent tooth.

According to Spatial Relation

The spatialrelation ship of the impacted tooth is taken in consideration with the distance from the distal of the second molar to anterior border of ramus in comparison with the mesio- distal diameter of the crown. Accordingly it is divided into

Class I: More than enough space available for the eruption of the tooth.
Class II: The space available and mesiodistal diameter of the crown coincides each other.
ClassIII: The space available is very less compared to the mesiodistal diameter of the crown.

In the study when considering the tooth canal distance was more in the case of position A impactions followed by Position B and Position C.

In case of the spatial relation the tooth canal distance was more for class I followed by class II and class III. This is mainly because most of the class III impactions will be deeply impacted coinciding to position C. All the findings recorded with the help of CS-3D software were tabulated.

FOR HORIZONTAL IMPACTIONS

In horizontal impactions the mean distance of the tooth from the canal with respect to each depth of the impactions were given as

Position A: 4.7 mm
Position B: 3.6mm
Position C: 1.4 mm

According to the spatial relationships the distance varied as follows

Class I : 4.1 mm
Class II: 3.7mm
Class III: 1.3 mm

for Mesio Angular Impactions

According to the depth of the impaction the values varied as

Position A: 4.7mm
Position B: 3.6mm
Position C: 1.4 mm

According to the spatial relationships the distance varied as follows

Class I: 4.0 mm
Class II: 3.8 mm
Class III : 1.4 mm

For Vertical Impactions

For vertical impactions the mean distance of the tooth from the canal with respect to the depth of the impaction were given as

Position A: 4.5 mm
Position B: 3.5 mm
Position C: 1.4 mm

According to the spatial relationships the distance varied as follows

Class I : 4.3 mm
Class II : 3.8mm
Class III: 1.3 mm

For Disto Angualar Impactions

The mean distance of the tooth from the canal for different depth of impactions were given as

Position A: 4.5 mm
Position B: 3.6 mm
Position C: 1.3 mm

According to the spatial relationships the distance varies as follows

Class I: 4.1 mm
Class II: 3.7 mm
Class III: 1.4 mm

CBCT is widely used as a diagnostic tool in recent years, even though its exposure parameters are high. The advantage of its diagnostic detailing has made it to be preffered by the clinicians. A retrospective study by *Komaligarlapati et.al* stated that cone beam computed tomography is preferred by general dental practitioners (25%) followed by oral and maxillofacial surgeons (23%). The CBCT is used as a diagnostic tool mostly in case of implant planning (61%) followed by impactions (15%). The most favourable factor to opt CBCT over conventional radiography is that their ability to obtain a 3-D reproduction of the area of interest. It is highly accessible and easy to handle. In our study the cross sectional view of the impacted mandibular third molar had been referred to measure the distance of the various parameters. *Mojdeh et.al* in his study evaluated the relationship between mandibular third molar and mandibular canal by different algorithms and compared the course of inferior alveolar canal with various views say cross sectional view, panoramic reproduction and 3-D reconstruction. The imaging technique using the cross sectional view was giving a better detailing of the course of the nerve compared to all other techniques.[26]

CONCLUSION

Accurate assessment of the relationship between the root apex of an impacted mandibular third molar and mandibular canal preoperatively is necessary to avoid injury to the mandibular canal. Panoramic radiography is a two dimensional imaging tool which is used routinely, limitation of which is lack of accurate details regarding relationship of impacted third molar with the mandibular canal in close approximation. Panoramic signs like darkening of the root, interruption of white cortical line, narrowing of mandibular canal, deflection of root or combinations of these signs are suggestive of close relationship of the tooth with the mandibular canal. In such circumstances more precise radiographic technique like cone beam computed tomography will provide accurate three dimensional informations like presence or absence of corticalization between the mandibular canal and the root apex, course of the mandibular canal, position of the mandibular canal with respect to the root, and even the root morphology. According to the results obtained from the study

cone beam computed tomography is recommended for evaluating the risk of mandibular canal injury preoperatively so that the surgeon can plan appropriate surgical procedure and take precautionary measures in order to avoid any untoward injury to the mandibular canal.

SUMMARY

This study was conducted in the department of Oral and Maxillofacial Surgery, Sri Siddhartha Dental College, Tumkur after getting the ethical clearance from the institution's ethical committee. The study was conducted from December 2017 to October 2018.

The aim of the study was to evaluate the position and orientation of the mandibular canal with impacted mandibular third molars three dimensionally using Cone Beam CT. CBCT radiographic records of 334 patients were evaluated and parameters evaluated were distance of inferior alveolar canal from the closest point on the tooth, distance of the inner and outer cortical plates from the centre of the canal and the distance of inner and outer cortical plates from the centre of the canal.

All the values were evaluated in cross sectional view using CBCT 3D CS software.

The distance of the inferior alveolar canal from the closest point on the impacted mandibular third molar was identified. Also its distance from the buccal and lingual cortical plates were evaluate. The variation in its distribution with respect to different age, gender, angulation and side was identified.

The present study suggests that cone beam computed tomography can be useful in case where panoramic radiography presents with the radiographic signs which are indicative of close relationship of the root apex to that of the mandibular canal

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