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Computed Tomography Evaluation of Marginal Alveolar Bone and Root Resorption in Anterior Mandible in Non Extraction Patients

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ABSTRACT
Objective: To evaluate marginal alveolar bone height and root resorption in the anterior mandible after orthodontic treatment to assess the correlation between morphologic and treatment changes.
Method:40 pretreatment and post treatment CBCT images (10 males and 10 female subjects)were used to measure cortical bone thickness and root resorption in anterior mandible. Changes in the cement enamel junction to the marginal bone crest distance were correlated with pre-treatment and post treatment changes
Result: Variation was seen among different subjects.There was an average of 1.12 mm of facial bone loss (F-CEJ-MBC), but the individual changes ranged from a 4-mm gain to an 8.8-mm loss.
Conclusion:A thinner mandibular symphysis at the tooth apex was associated with an increase in facial vertical bone loss.Thinner pretreatment cortical bone at the apex level was correlated with greater facial vertical bone loss. No significant root resorption was seen in anterior mandibular before and after orthodontic treatment.

I. INTRODUCTION

Orthodontic objectives consists of obtaining the best aspects in facial esthetics, an efficient masticatory apparatus stable treatment results and healthy dental and periodontal tissues.

The alveolar bone response to orthodontic toothmovement depends on force levels, the type and extentof tooth movement and the presence of dental plaque. There is no evidence of a relationship betweentreatment time and alveolar bone resorption or influence of extraction or non-extraction treatment on alveolar bone resorption. Orthodontic treatment effects on the heights of the alveolar bone crest (AC) have been studied radiographically, with some investigationsshowing reduction on their height and others, noreduction.

The tissue response to orthodontic forces enables teeth to be moved in the alveolar bone but can also result in adverse side effects. Most research has focused on orthodontically induced inflammatory root resorption however factors which cause root resorption may also negatively affect the alveolar bone.[1]

Most studies evaluating alveolar bone height have used bitewing or periapical radiography and have focused on the posterior dentition. Orthodontists have historically relied on 2-dimensional (2D) imaging for diagnosis andtreatment planning as well as to monitor treatment progress and growth.[2]

With the introduction of 3-dimensional (3D)imaging,practitioners can now visualize and measure true 3Danatomies of patients. Many CBCTunitsallowthepractitioner toselectadeterminedfieldofview (FOV)basedon the structures,whichmustbe visualized. Thisisdesirable becausethe irradiatedfieldmaybe limitedCBCT has allowed far more extensive studies for evaluation of alveolar bone height in the anterior region.

As there is lack of studies evaluating alveolar bone changes and root resorption before and after orthodontic treatment, the aim of the present study was to investigate the marginal bone &root resorption in mandible using CBCT before and after orthodontic treatment.

II. MATERIAL AND METHOD

The present study was conducted in the Department of Orthodontics and DentofacialOrthopaedics, Jaipur Dental College, in co-ordination with Private Radiology clinic for CBCT examination. This study was approved by the ethical committee. The study was pursued with the written informed consent obtained from the patients or their parent (in case of minor) before entering the study.

Materials:-

The study was based on pretreatment and post treatment of 20 patients A total of 40 CBCT images (20 pretreatment and 20 post treatment) pertaining to 10 males and 10 female subjects, ages 18.5 to 28.5 were selected randomly from the patients visiting the OPD of Dept. of Orthodontics,

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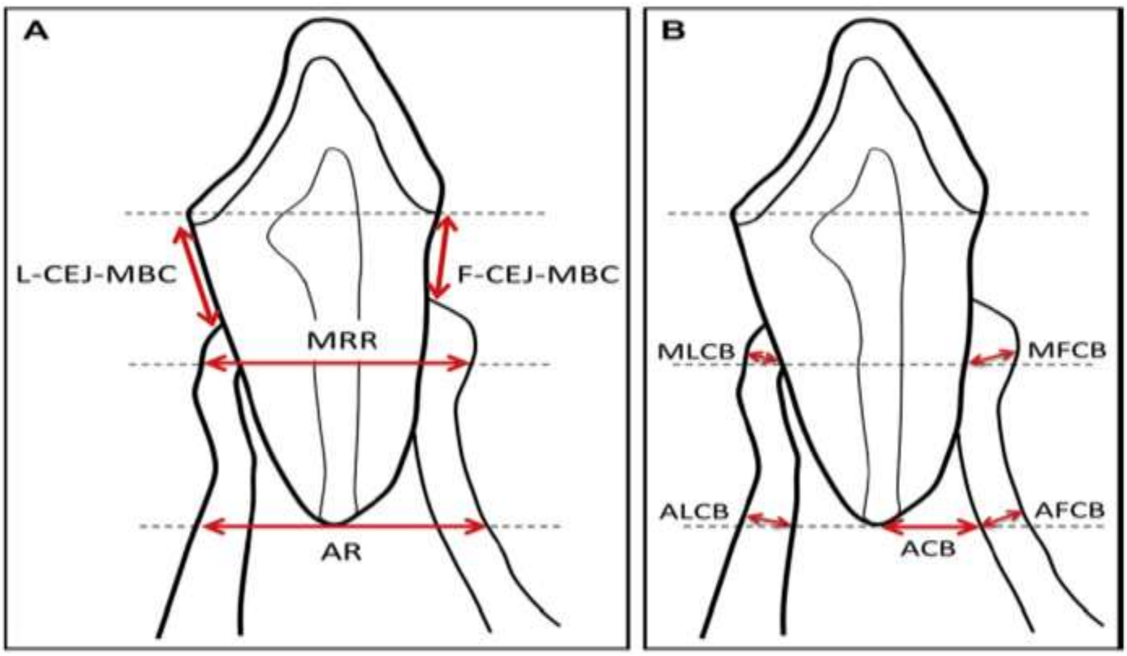
Jaipur Dental College. Only patients who satisfied following inclusion criteria were selected for the study: Class I with minimal crowding and Class I bimaxillarydento-alveolar protrusion malocclusion, a permanent dentition with all second molars completely erupted, a good periodontal health, expansion therapy not considered.

The treatment protocol was standardized using an MBT (McLaughlin, Bennett, Trevisi) pre-adjusted appliance (3M Unitek Orthodontic Products; Monrovia,CA, USA) with 0.022-inch slots. Initial levelling and alignment were performed using round, heat-activated, nickel titanium wires. Space closure was performed using rectangular 0.019 9 0.025-inch stainless steel wires. Class I elastics were mainly used and sometimes additional Class II elastics. Mean treatment (SD) duration was 20.7 (5.7) months [median (range) 20.0 (11–43) months]. The oral hygiene was continuously monitored.

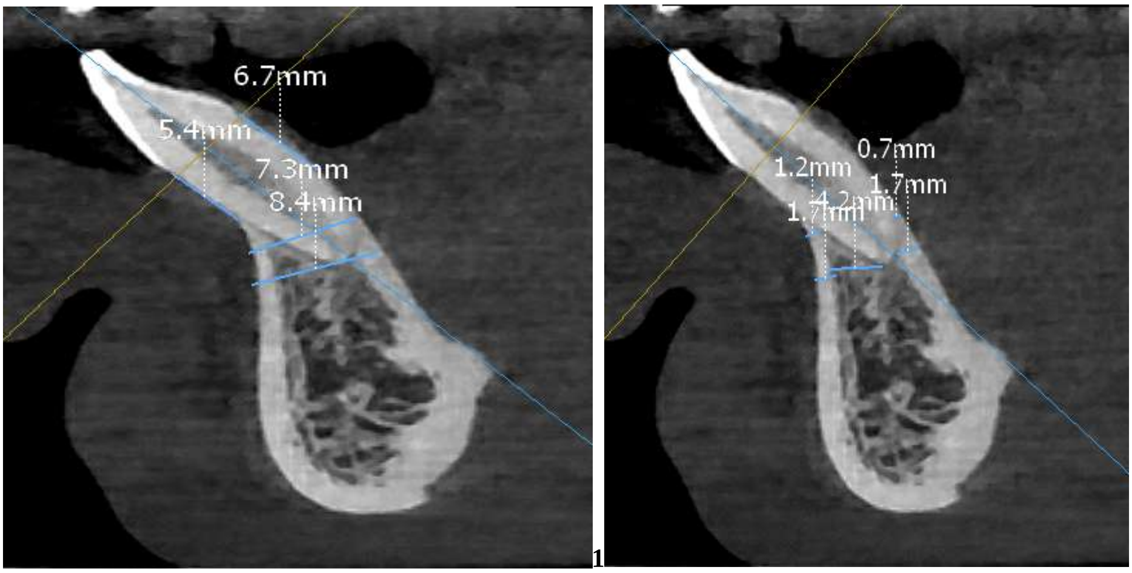
Each subject was seated in a chair with his or her Frankfort horizontal (FH) plane parallel to the floor. A CBCT device (VATECH PAX I 3D smart scanner) was set to 94 kV/8 mA with an exposure time of 13 s. Each 3D image consisted of 512 slices; with a slice thickness of 0.38 mm. Data were stored in Digital Imaging and Communications in Medicine (DICOM) format. The CBCT images were obtained with VATECH PAX I 3D smart scanner with a single 360 degress rotation, producing 306 basis images. All images had a medium or full field of view that allowed visualization of both the cranial base and the face.

To examine the morphologic features of the alveolar bone, each CBCT image was oriented along the long axis of the mandibular right central incisor (bisecting the pulp and the canal) in the sagittal and coronal planes, and bisecting the canal in a labio-lingual direction in the axial plane at the same time . Only the right side was measured because there are no side differences in cortical bone thickness. Once oriented, a sagittal cross section of the mandibular right incisor was produced. From this image, measurements from the labial (F-CEJ-MBC and lingual (L-CEJ-MBC) aspects were made from the most apical portion of the cemento-enamel junction (CEJ) to the most coronal aspect of the marginal bone crest.

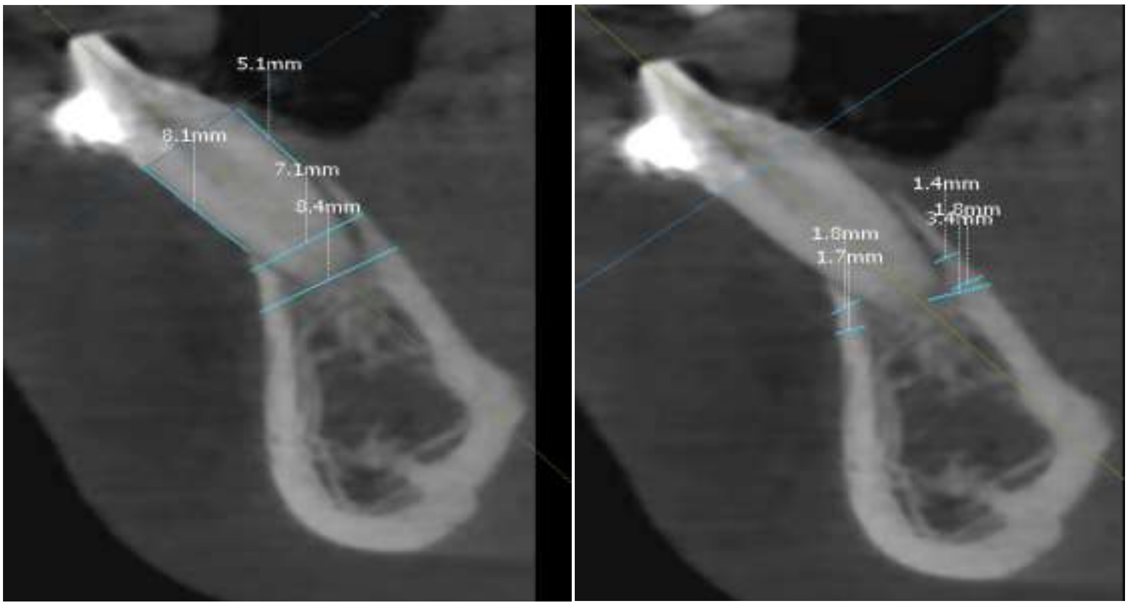
Cortical bone thickness (ALCB and AFCB), and distance (ACB) is from the apex to the internal border of the labial cortical bone. Cortical bone thickness was measured as the line from the point where the horizontal line intersected the internal border of the cortical plate, perpendicular to the external border of the cortical plate.



Measurment from CBCT: A. Distance from the CEJ to marginal bone crest(L-CEJ-MBC,F-CEJ-MBC), and ridge thickness (MRR,AR); B, cortical bone thickness at midroot level (MLCB,MFCB) and apex level (ALCB,AFCB).Distance from apex to internal border of the facial cortical bone(ACB).



Pre-treatment measurement from CBCT

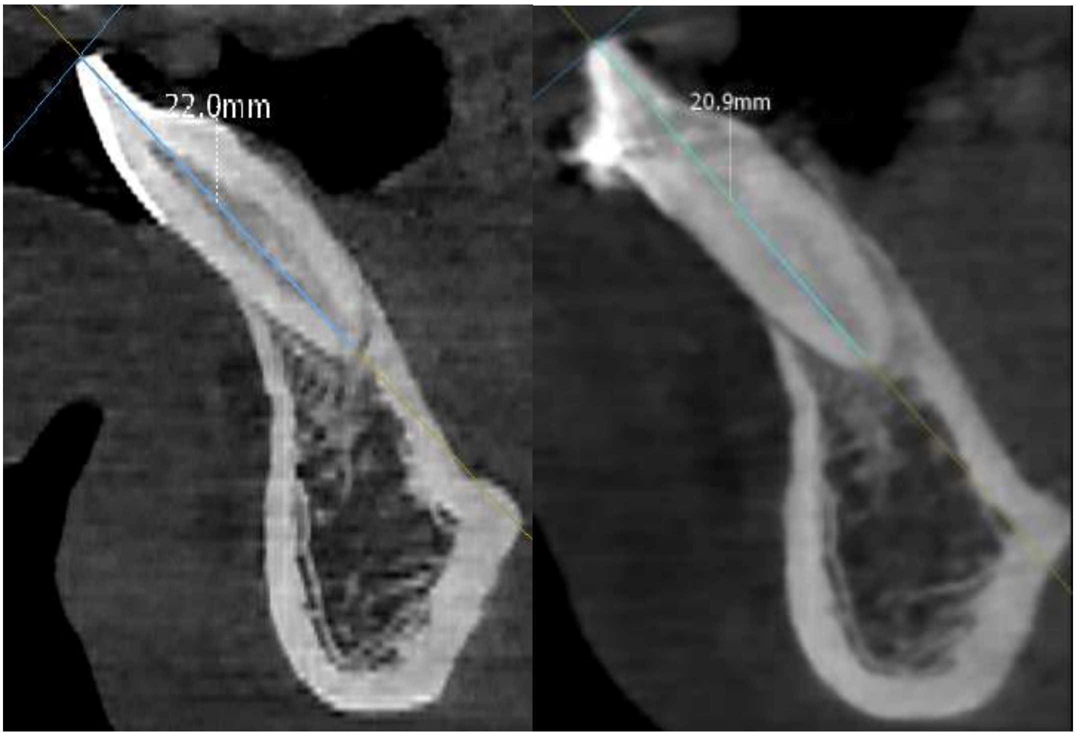


post treatment measurement from CBCT

Evalution of root resorption

To evaluate changes in root resorption, CT images were taken pre-treatment and post-treatment. Reconstructions were made so that the axial slices became perpendicular to the long axis of the tooth/root. This provided optimal visualization of the tooth/ root in axial, coronal, and sagittal planes.

A reference point for measurements were as follows:-incisal edge to apex of central & lateral incisors and cusp tip to apex of canines. The same measurements were repeated after completion of treatment. Post-treatment measurements were taken at the same slice levels as the pre-treatment measurements.



Pretreatment & Post-treatment Measurement CBCT

III. RESULTS

Results of the study were presented in the form of tables.

Table:-1 Statics for bony changes.

	T1		T2		T2-T1		t test
Variables(mm)	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**P value**
F-CEJ-MBC	1.90	1.89	3.06	2.46	1.12	2.26	<0.01
L-CEJ-MBC	2.18	2.12	3.51	3.00	1.33	2.50	<0.01
MFCB	0.75	0.38	0.65	0.40	-0.10	0.38	0.05
MLCB	1.04	0.58	0.76	0.59	-0.29	0.53	<0.01
AFCB	1.93	0.36	1.87	0.50	-0.06	0.41	0.24
ALCB	2.32	0.55	2.07	0.68	-0.25	0.65	0.01
MRR	7.38	1.11	7.17	0.99	-0.21	0.70	0.02
AR	10.2	2.31	10.20	2.46	-0.04	1.00	0.75

Table:-1 Positive numbers for CEJ-MBC values represents an increase in distance from the CEJ-MBC (bone loss), and negative numbers for CEJ-MBC values represent a decrease in distance from the CEJ-MBC (bone gain); for all other variables, a negative number represents thinning of bone, and a positive number represents bone thickening.*Significant (P #0.05).

Table:-2 Distance changes between the pretreatment and post treatment cemento-enamel junction and the marginal bone crest on the facial and lingual surface

	N	<-4mm	-4>-2mm	->0mm	0<2mm	2<4mm	4<6mm	6<8mm
F-CEJ-MBC	**40**	**1(1.8)**	**1(1.8)**	**10(17.5)**	**15(54.3)**	**6(8.8)**	**4(8.8)**	**3(7)**
L-CEJ-MBC	**40**	**1(1.8)**	**1(1.8)**	**11(19.3)**	**18(57.8)**	**3(5.3)**	**4(10.5)**	**2(3.5)**

Table:-2 A negative number means that the CEJ-MBC post treatment distance was shorter than the pretreatment distance, representing bone gain, and a positive number mean that the CEJ-MBC post treatment distance was greater than the pretreatment distance, representing bone loss. Values are shown as n (%)

Table:-3 Correlations of pretreatment variables with facial and lingual cemento-enamel junction to marginal bone crest distance changes

F-CEJ-MBC			L-CEJ-MBC	
	R	**P**	**R**	**P**
ACB T1	-0.18	0.17	0.10	0.48
AFCB T1	-0.33	0.01	0.18	0.17
ALCB T1	-0.27	0.04	-0.01	0.96
MFCB T1	0.10	0.44	-0.34	0.01
AR T1	-0.31	0.02	-0.05	0.72
MRR T1	-0.13	0.36	-0.25	0.06

Table :- 3 *Correlation is significant at the 0.05 level (2-tailed); y correlation is significant at the 0.01 level (2-tailed)

Table:-4 Correlations of treatment change variables to facial and lingual cemento-enamel junction to marginal bone crest distance changes

	F-CEJ-MBC		**L-CEJ-MBC**	
	R	**P**	**R**	**P**
APEX	0.30	0.02	-0.18	0.18
ACB	-0.39	<0.001	0.23	0.09
ALCB	0.31	0.02	-0.45	<0.001
MFCB	-0.59	<0.001	0.43	<0.001
MLCB	0.39	<0.001	-0.49	<0.001

Table :- 4 *Correlation is significant at the 0.05 level (2-tailed) correlation is significant at the 0.01 level (2-tailed). Correlation is significant at the 0.01 level (2-tailed).

Root resorption:-

Table:-5 Initial & final measurement obtained by teeth (in millimeters)

Tooth	T1	SD	T2	SD	T2-T1	P
CENTRAL INCISOR	21.61	1.49	21.20	1.51	-0.40	<.001
LATERAL INCISOR	22.84	1.45	22.36	1.44	-0.47	<.001
CANINE	25.75	1.97	25.63	2.00	0.12	.162

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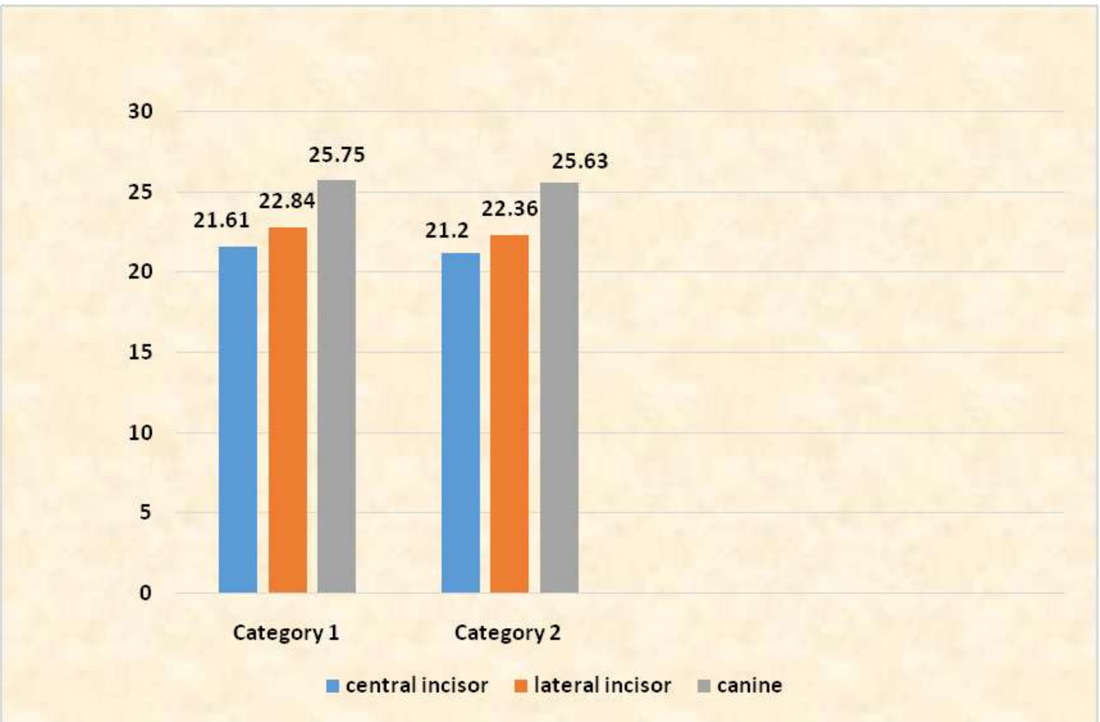

APICAL ROOT RESORPTION VALUE IN ROOTS

IV. DISCUSSION

Orthodontic movement can be quick or slow, depending on the physical characteristics of the applied force, the size and the biological response of the periodontal ligament. According to Vardimon, Oren and Ben-Bassat, there is an axiom in orthodontics that says: "tooth movement leaves marks on the bone", however, this fact is not always favorable.

According to several authors the morphology of the lingual and buccal bone plates should be determined before orthodontic treatment using radiographs to carefully plan treatment and to avoid the appearance of alveolar bone dehiscence or to minimize its frequency.

Cone beam computed tomography (CBCT) emerged in the late 1990s as an appropriate technique to assess marginal bone changes. It provides images in which anatomical structures

Table 1-All bony changes were statically significant except for the facial apex-level cortical bone thickness changes (AFCB) and the apex-level ridge thickness changes (AR)

Table 2-Most of the variables showed large variations among subjects. For example, there was an average of 1.12 mm of facial bone loss (F-CEJ-MBC), but the individual changes ranged from a 4-mm gain to an 8.8-mm loss. Similarly, there was an average of 1.33 mm of lingual bone loss (L-CEJ-MBC), with a range of 5.6 mm of bone gain to 8.8 mm of bone loss. Table II gives the range of CEJ-MBC distance changes, organized in 2-mm increments and shown as percentages of the sample.

Table 3-There were no correlations between lingual CEJ-MBC distance changes and any of the variables describing pretreatment tooth position.

Table 4-There were no correlations between lingual CEJ-MBC distance changes and changes in tooth position.

Although wide ranges of bone losses and gains occurred, the average amounts of bone recession observed on the facial (1.12 mm) and lingual (1.33 mm) surfaces were greater than previously reported by some and less than reported by others.

Using bitewings to evaluate posterior interdental vertical bone height, 0.5 mm and 0.13 mm of bone loss has been reported in patients orthodontically treated compared with an untreated group. Lund et al,[9] who used CBCT to evaluate marginal bone crest levels of the anterior mandible in patients treated with mandibular premolar extractions, found an average of 5.7 mm of bone loss on the lingual surface.

Pretreatment ridge thickness is associated with vertical bone loss in patients treated orthodontically. The results in this study showed that the thinner the ridge at the level of the mandibular incisor apex, the more facial bone loss can occur. It has been previously reported that more dehiscence occurred in patients with thin symphysis than those with a thick symphysis.

It has been shown that a thin symphysis is associated with thinner cortical bone and when cortical bone thickness decreases, so too does bone density. Therefore, in patients with thinner ridges, and thus thinner and less dense cortical bone, the alveolus could be more prone to microfractures associated with tooth movement, resulting in increased vertical bone loss.It also appears that pretreatment cortical bone thickness is linked to facial vertical bone recession. There were weak negative correlation of -0.33 and -0.27 between facial vertical bone recession and both the pretreatment facial and lingual cortical bone thicknesses (both at the apex level). Based on 11 subjects, Fuhrmann[4] reported that small symphysis with reduced labiolingual bone widths, frontal crowding, and thin facial or lingual cortical bone were risk factors for bone dehiscence.

It also appears that when vertical bone recession does occur, the thickness of the cortical bone changes. It was observed that on the surface where vertical bone recession happened, thinning of the cortical bone on the same side also occurred, whereas the opposite side showed less cortical bone thinning. This observation makes sense if it is assumed that it was translation of the tooth, not tipping of the tooth that caused bone loss. For example, if a tooth begins in a more lingual position in the ridge, it will potentially occupy space in the lingual cortical bone. If it is then moved labially to occupy space in the facial cortical bone, the lingual cortical bone will effectively get thicker, and the facial thickness will be thinner. This would be especially true if the ridge width is thin.

Sarikaya et al[6] found that the lingual alveolar bone of the mandible decreased significantly over the central incisors (at the crest, midroot, and apex levels) in patients who had 4 first premolars extracted, even though the labial bone maintained its thickness.This suggests that the bone thins as a tooth or root approaches cortical bone. However, as a tooth or root distances itself from the cortical bone, bone thickness does not change.It appears that the closer the root apex is moved toward the facial cortical bone during treatment, the more facial bone recession occurs.

A weak negative correlation (-0.39) was found between facial bone recession and the change in mandibular incisor apex position during treatment.

Yu et al[7]concluded that when teeth are facially proclined, the root apex approximates the lingual cortical plate, indicating that proclination alone will not move the apex forward. Therefore, the apex can move closer to the facial cortical bone only through uncontrolled lingual crown tipping, translation in the labial direction, a combination of these, or proclination accompanied with labial bodily movement

Root resorption:-

This study aimed to determine the frequency of RR using CBCT. Although a number of studies have already evaluated RR using CBCT images, the present study allowed a total view of resorption The conventional two-dimensional imaging methods show a high frequency of ARR after orthodontic treatment. However, CBCT images provide a more accurate analysis of treatment results. In this study, the difference in tooth length before and after orthodontic treatment, measured using three-dimensional images, defined RR frequency our results showed that minimal root resorption in non-extraction Class I malocclusion treatments.

Table 5-The frequency of ARR was high in mandibular central incisors (72%), mandibular lateral incisors (70%).

In some previous studies RR prevalence rates ranged from 43% to 51%. Higher frequencies were found in other studies.

Jansonet al.[5] used periapical radiographs and found an ARR prevalence of 97.75% in roots of maxillary and mandibular incisors after orthodontic movement.

Linge and Linge[3] described a method to quantify root resorption in which measurements were made on periapical radiographs before and after treatment. Their reference points included the distance from the cemento-enamel junction to the root apex, and the correction of magnification was based on the ratio of crown length obtained on the radiographs before and after treatment. The measurement of root resorption was technically complex in this method. Changes in tooth length, due to magnification radiographic technique, difficulty locating the junction cemento-enamel, and variations in the incidence of X-rays, were considered a limiting factor of this method.

Estrela et al[8] used the i-CAT software and three-dimensional images and suggested a quantitative method to evaluate inflammatory root resorption according to the root third and surface and the extent of root resorption. In our study, the acquisition of images using CBCT and the software measuring tool ensured precise measurements from incisal edge or cusp to the root apex without the limiting factors associated with two-dimensional radiographs.

The association between orthodontic treatment and root resorption has been widely studied, but the comparison of the results is difficult as a result of differences in treatment techniques, radiographic evaluation criteria, and diagnostic imaging methods.Although CBCT provides an accurate assessment of ARR and no overlapping images further studies should be conducted to justify its routine use in orthodontic treatment planning. The indication of CBCT imaging studies should be evaluated carefully, with consideration of the risks and benefits.

V. CONCLUSION

The present study evaluated marginal alveolar bone & root resorption in the anterior mandible with computed tomography before and after orthodontic treatment in non-extraction patient. The conclusions of this study as follow:-

1. A thinner mandibular symphysis at the tooth apex was associated with an increase in facial vertical bone loss.
2. Thinner pretreatment cortical bone at the apex level was correlated with greater facial vertical bone loss.
3. Thinning of cortical bone occurs on the surface undergoing vertical bone loss.
4. Movements of the mandibular incisor apex moving toward cortical bone produce greater amounts of vertical bone loss

Root resorption:-

CBCT was effective for detecting even minimal degree of root resorption in vivo due to orthodontic treatment and allowed three dimensional evaluation of dental root. There was no significant root resorption in anterior mandibular before and after orthodontic treatment.

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