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A Comparative Evaluation of Changes in Alveolar Bone Around Upper Central Incisors in Extraction and Non-Extraction Patients Using Cone-Beam Computed Tomography

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ABSTRACT

Background: In this study, individuals undergoing orthodontic therapy with and without extractions were compared and evaluated for changes in alveolar bone thickness and vertical height at the crest area surrounding upper central incisors using cone beam computed tomography (CBCT).
Method: In cooperation with the Oral Radiology Department, the Department of Orthodontics and Dentofacial Orthopaedics at Jaipur Dental College performed this retrospective CBCT study. Pre-treatment CBCT records from 15 non-extraction patients whose initial spacing was greater than 3 mm and 15 extraction patients whose initial crowding was greater than 5 mm were included in the study. Post-treatment CBCT scans were taken after alignment and leveling to assess and compare vertical bone loss and alveolar bone length on the labial and palatal sides of the maxillary central incisors.
Results: Following extraction cases after alignment and leveling, there was a statistically significant difference (p0.05) in the vertical bone loss on the palatal side of central incisor between the extraction and non-extraction groups. For every other measure, however the differences between the groups were statistically not significant ($p>0.05$)
Conclusion: While there was a greater loss of vertical bone on the palatal side, there was no appreciable difference in the amount of alveolar bone lost in extraction cases compared to non-extraction instances.

Keywords: cone beam computed tomography, alignment and leveling, vertical bone height, alveolar bone height.

INTRODUCTION

A consistent treatment outcome, improved periodontal health, improved masticatory system, improve occlusion, and improved facial and dental aesthetics are the main objectives of orthodontic therapy[1]. The force applied, the kind and degree of tooth movement, and the patient's dental hygiene all affect how the alveolar bone responds to orthodontic treatment.[1]

As it defines the posture of the upper lip and greatly enhances the appearance of a smile, the upper incisor is an important component of aesthetics. Maintaining anterior tooth torque is essential during orthodontic treatment because it impacts the alveolar bone's inclination.[1]

Stable occlusion and improved periodontal health are benefits of having teeth positioned correctly in the center of the alveolus.[2] A number of studies have documented that excessive retraction of anterior teeth following orthodontic treatment may lead to iatrogenic problems like gingival recession, dehiscence, alveolar bone loss, and fracture. To prevent these negative effects, it is crucial to comprehend the alveolar bone's genuine capacity for remodeling. [3]

Extraction of teeth is to treat protrusion and crowding. Retraction of the anterior teeth uses the space left by extraction to realign the dentition, restructure the alveolar bone, and lessen facial convexity.[3]

To provide room for the retraction of anterior teeth, premolar extraction is frequently required. It is imperative to maintain appropriate torque control during this retraction, but DOIng so presents a biological difficulty, particularly in individuals with substantial skeletal discrepancies or narrow alveolar bone width. In cases when the incisor apices come into contact with dense cortical plates during retraction, these patients are more vulnerable to a significant iatrogenic loss of periodontal support. [4]

Cone-beam computed tomography (CBCT) offers an enhanced technique for evaluating bone support by analysing certain locations in three dimensions. When compared to conventional radiography, CBCT provides true-to-scale, high-definition pictures that are free of aberrations and structural superimposition, guaranteeing greater accuracy. Owing to these benefits, the preferred technique for precisely determining the alveolar bone's size is CBCT.[2] To better understand the marginal bone level with the cementoenamel junction (CEJ) at the buccal and palatal/lingual tooth surfaces in adolescents prior to orthodontic treatment involving premolar extractions, this study used CBCT with a small voxel size and a short field of view (FOV). It also aimed to evaluate the frequency and magnitude of changes in marginal bone level

following alignment and leveling.[5]

Therefore, the purpose of this study was to examine and evaluate, using CBCT, changes in alveolar bone thickness and vertical alveolar bone loss around maxillary central incisor teeth in patients undergoing extraction versus those not, both before and after alignment and leveling.

MATERIALS & METHODS

In collaboration with the Oral Radiology Department, the Department of Orthodontics and Dentofacial Orthopaedics at Jaipur Dental College carried out this retrospective CBCT investigation. The university's ethical committee approved the trial, and each patient who participated provided written informed consent.

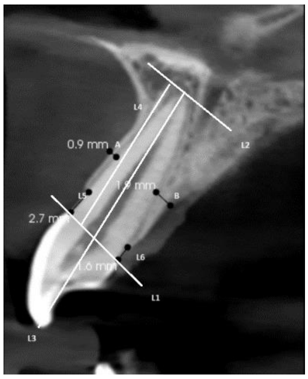
The study included 30 patients aged 15-28 years, divided into two groups: 15 patients who underwent first or second premolar extractions and 15 patients who did not undergo extractions. Pre-treatment CBCT scans were taken for both groups, focusing on the anterior maxillary bone. Premolar extractions were performed in cases with anterior crowding greater than 5mm, prior to alignment and leveling. Non-extraction cases were selected based on anterior spacing greater than 3mmConditions for inclusion complete set of permanent teeth aside from the third molars, for extraction situations, anterior crowding must be more than 5 mm, and for non-extraction cases, it should be less than 5 mm. Criteria for exclusion Before orthodontic care, missing, removed, or excessive teeth, unruptured primary molar, a crossbite, or first-molar restoration, skeletal or facial asymmetry , or craniofacial abnormalities, periodontal or periapical diseases are present, Past medical history pertaining to jaw surgery, trauma, cancer, deformed teeth, anodontia, or oligodontia, any disease that affects the metabolism of bone in the body. With the patient in their natural head position, all CBCT scans were performed so that the Frankfurt Horizontal Plane and the lower boundaries of the orbit lined up. Using a consistent exposure configuration, scans were conducted with the CS 8200 3D CBCT system (Carestream Dental LLC, Atlanta, GA) with voxel dimensions of 150µm x 150µm x 150µm, tube voltage of 73kV, and scanning time of 20 seconds. Digital Imaging and Communication in Medicine, or DICOM, format was used for recording the data, and CS 3D Imaging (Carestream) software was used for processing.

Measurements

Reference points including the apex, long axis, and cementoenamel junction (CEJ) were used in this study to measure changes in alveolar bone. The labial and palatal surfaces of the maxillary central incisors teeth were measured, with the measurements taken perpendicular to the CEJ, to determine the amount of vertical bone loss.

On both the labial and palatal sides, alveolar bone thickness was measured at the mid-root. Both before and after orthodontic treatment, these measurements were showed in figure 1

Figure 1: A diagram showing the measurements and reference lines utilized in the research.



Parameters Assessed

The following criteria and techniques were applied in order to assess maxillary central incisor alveolar bone thickness (AMABT) and vertical alveolar bone height:

Perspective Axial: The intersection of the horizontal and vertical orientation lines was established at the central incisor. Coronal View: Along the tooth's long axis, a vertical orientation line was placed.

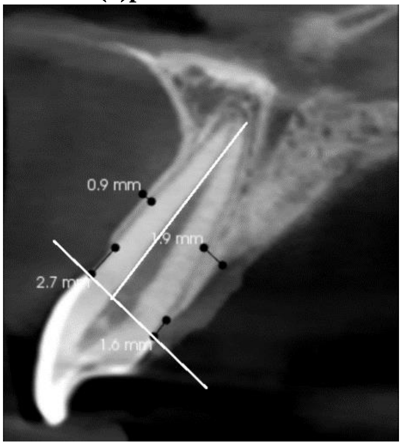
in Sagittal View the tooth's long axis was aligned with a vertical line, and a horizontal line was drawn at the CEJ. Vertical alveolar bone height on the labial and palatal sides, as well as AMABT at the mid-root, were measured for the Sagittal Reconstruct showed in table 1.

Table1. Illustration of reference lines and measurement used in the study.

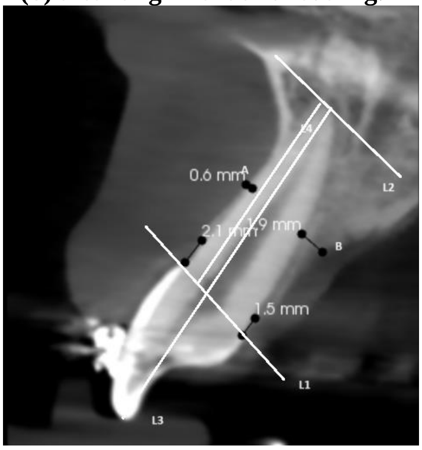
Reference line and measurement	Definition
L1	Line along the CEJ of the tooth
L2	Line perpendicular to the long axis of tooth at the apex of tooth
L3	Long axis of the tooth
L4	Length of the root from the apex
L5	Vertical bone loss on labial side of the tooth
L6	Vertical bone loss on palatal side of the tooth
A	Labial alveolar bone at the mid of root
B	Palatal alveolar bone area at mid of root

Figure 2: Measurement of alveolar bone thickness and vertical bone loss (a)pre-treatment (b) after alignment and leveling.

(a)pre-treatment



(b) after alignment and leveling.



STATISTICAL ANALYSIS

Data obtained was compiled on a MS Office Excel Sheet (v 2019, Microsoft Redmond Campus, Redmond, Washington, United States) was subjected to statistical analysis using Statistical package for social sciences (SPSS v 26.0, IBM). Descriptive statistics like frequencies and percentage for categorical data, Mean & SD for numerical data has been depicted. Normality of numerical data was checked using Shapiro-Wilk test & was found that the data did not follow a normal curve; or for graded data, hence **non-parametric tests** have been used for comparisons.

Inter group comparison (2 groups) was done using Mann Whitney U test.

For all the statistical tests, $p<0.05$ was considered to be statistically significant, keeping α error at 5% and β error at 20%, thus giving a power to the study as 80%.

RESULT

As shown in **Table 2**, When comparing cases with and without extraction, there is a statistically significant difference ($p<0.01$) in the amount of vertical bone loss, with the palatal side experiencing more vertical bone loss after alignment and leveling than the labial side. There were no variations in alveolar bone loss between the extraction and non-extraction cases, no any other variables exhibit statistically significant changes ($p>0.05$) between the groups.

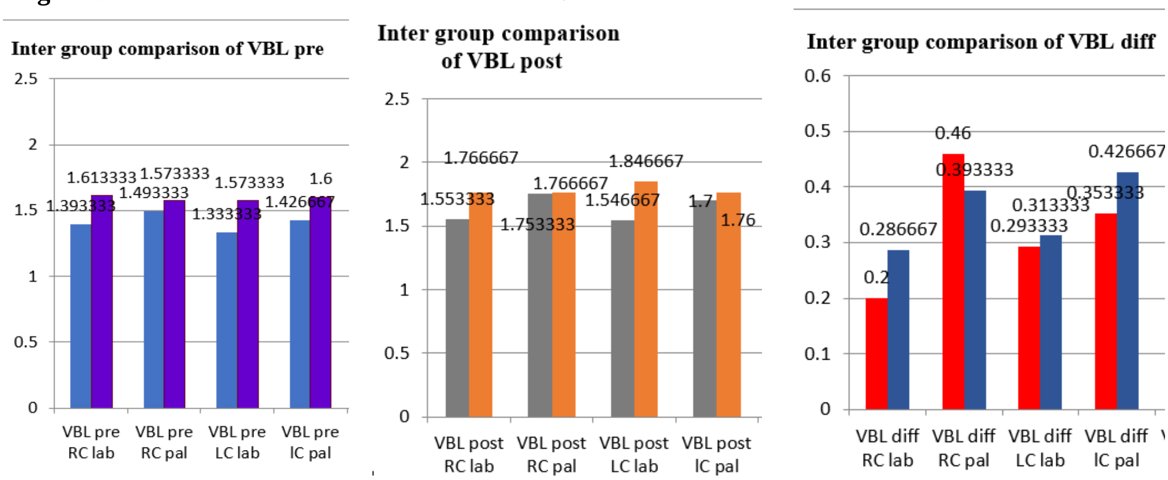
Table 2. Inter group comparison of Variables between extraction and non- extraction cases before treatment and after alignment and leveling.

Group	N	Mean	Std. Deviation	Mann-Whitney U value	Z value	P-value
VBL Pre RC lab 1	15	1.393333	.5006662	85.000	-1.145	0.252#
2	15	1.613333	.4172472			
VBL Pre RC pal 1	15	1.493333	.5119524	103.500	-0.374	0.708#
2	15	1.573333	.5522249			
VBL Post RC lab 1	15	1.553333	.6034030	93.000	-0.813	0.416#
2	15	1.766667	.3244042			
VBL Post RC pal 1	15	1.753333	.6885457	106.500	-0.250	0.802#
2	15	1.766667	.5524836			
VBL diff RC Lab 1	15	.200000	.1133893	83.000	-1.275	0.202#
2	15	.286667	.1726543			
VBL diff RC Pal 1	15	.460000	.3850788	85.500	-1.138	0.255#
2	15	.393333	.4589844			
VBL pre LC lab 1	15	1.333333	.3885259	75.000	-1.564	0.118#
2	15	1.573333	.4817626			
VBL Pre LC pal 1	15	1.426667	.5897538	100.000	-0.521	0.603#
2	15	1.600000	.7211103			
VBL post LC lab 1	15	1.546667	.4882427	76.500	-1.503	0.1333

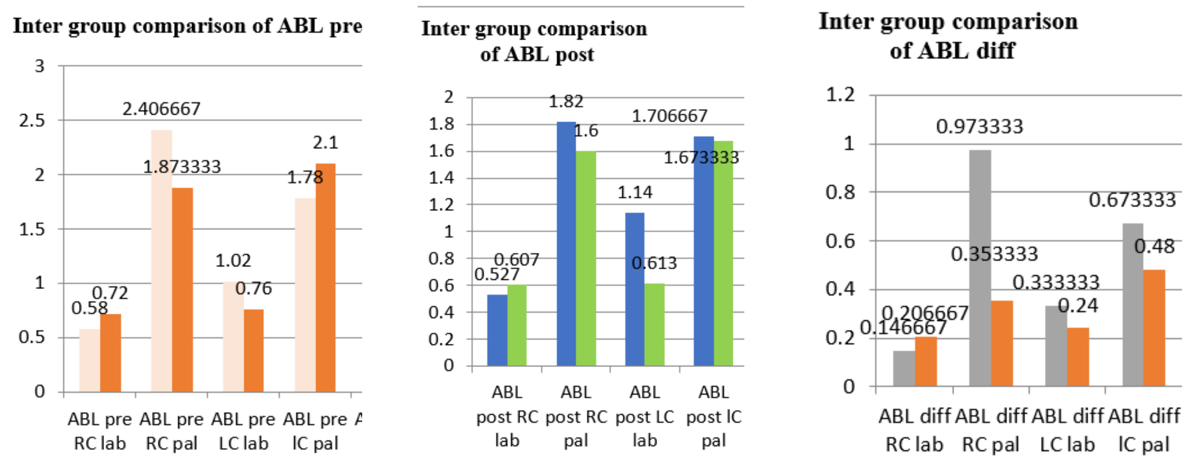
	2	15	1.846667	.5409868			
VBL post LC pal	1	15	1.70000	.720100	110.000	-0.105	0.917#
	2	15	1.76000	.758600			
VBL Diff LC lab	1	15	.293333	.2840188	1.1.000	-0.482	0.630#
	2	15	.313333	.2294922			
VBL Diff LC pal	1	15	.353333	.5054936	91.000	-0.909	0.364#
	2	15	.426667	.4742915			
ABL Pre RC lab	1	15	.58000	.242600	88.000	-1.027	0.035#
	2	15	.72000	.312100			
ABL Pre RC pal	1	15	2.406667	1.4606587	86.500	-1.080	0.280#
	2	15	1.873333	1.0361099			
ABL Post RC lab	1	15	.52700	.218700	86.000	-0.695	0.487#
	2	15	.60700	.263100			
ABL Post RC pal	1	15	1.82000	1.5767054	112.000	-0.021	0.983#
	2	15	1.60000	1.0085350			
ABL diff RC lab	1	15	.146667	0.0990430	80.000	-1.410	0.159#
	2	15	.206667	0.1387015			
ABL diff RC pal	1	15	.973333	1.2903303	94.000	-0.775	0.439#
	2	15	.353333	.1922300			
ABL Pre LC lab	1	15	1.020	1.1079	90.000	-0.946	0.344#
	2	15	.760	.2586			
ABL Pre LC pal	1	15	1.780000	1.2979104	89.500	-0.957	0.339#
	2	15	2.100000	1.357817			
ABL Post LC lab	1	15	1.140	1.3244	108.000	-0.188	0.851#
	2	15	.613	.2875			
ABL post LC pal	1	15	1.706667	1.2504095	112.500	0.000	1.000#
	2	15	1.673333	.8154461			
ABL diff LC lab	1	15	.333333	.321949	95.000	-0.35	0.462#
	2	15	.240000	.2292846			
ABL diff LC pal	1	15	.673333	.9720866	109.000	-0.148	0.883#
	2	15	.480000	.671986			

statistically significant difference (p<0.05), ** statistically highly significant difference (p<0.01) # nonsignificant difference (p>0.05).

Graph 1 Comparing the intergroup differences in vertical bone loss before and after post-alignment and leveling between extraction and non-extraction cases.



Graph 2 Comparing the alveolar bone loss in extraction versus non-extraction instances between groups both before and after post-alignment and leveling



DISCUSSION

Orthodontic tooth movement inevitably leads to changes in the bone surrounding the alveolar socket. During the eruption of teeth, the alveolar ridge undergoes simultaneous Augmentation. [6,7] Handelman has highlighted the fact that an insufficient or thin alveolus cavity for the planned tooth movement can raise the possibility of unfavourable orthodontic outcomes including root resorption, fenestration, and bone dehiscence.[8] One known risk factor for bone dehiscence is crowding. The apical migration of the marginal buccal bone and a decrease in buccal bone thickness can be brought on by tipping and expansion movements. [8] When it comes to orthodontic treatment decisions involving the anteroposterior and vertical movements of incisors, the thin maxillary anterior bone is quite important.[9]

In orthodontic treatment, particularly when premolar extractions are performed, the retraction of anterior teeth is necessary to achieve treatment goals, especially in cases of dental protrusion.[10,11] The upper incisor is a key element in orthodontic therapy due to its aesthetic significance in defining the position of the upper lip, which is essential for a pleasing smile. [12]

Achieving ideal occlusion, face attractiveness, and long-term stability require proper tooth torque.[2]

For cases where crowding is addressed without extractions, methods such as the distal movement of posterior teeth, arch expansion, and incisor proclination can be used.[13] Aesthetic and functional results are dependent on the thickness of the maxillary anterior facial bone.[14]

After tooth extraction and healing in the maxillary anterior region, cortical bone loss often occurs, with more pronounced bone loss on the facial side compared to the palatal side.[15] During anterior tooth retraction, a combination of bodily movement and tipping can lead to increased stress on the lingual alveolar crest, causing more bone loss in this area. Therefore, effective repair of the lingual alveolar bone is essential for maintaining treatment stability and protecting periodontal health.[16]

Excessive labial or palatal tooth movement has been linked to irreversible bone loss, according to previous research.[17] Therefore, major anterior tooth retraction requires cautious planning. Additionally, some studies have suggested that receiving orthodontic treatment may cause gingival recession and marginal alveolar bone loss. [18,19] To monitor changes in bone height and guarantee the effectiveness of orthodontic therapy, Aass and Gjermo advise long-term follow-up assessments of alveolar bone.[5] Maspero et al. found no significant changes in the levels of lingual vertical bone, although they did notice a substantial loss of labial vertical bone at the maxillary central incisors (0.5 mm).[20] On the other hand, no appreciable alterations in the labial or lingual vertical bone levels in maxillary incisors were discovered by Castro et al.[21] According to Morais et al., there was a notable decrease in the height and thickness of the buccal alveolar bone at the central incisors. These results were in line with those of previous CT and CBCT investigations.[22] According to Lund et al., there was a higher loss of palatal vertical bone than labial bone.[5]

CONCLUSION

In this study, pretreatment CBCT scans were obtained from 15 extraction cases and 15 non-extraction cases at Jaipur Dental College, with participants aged 15-28 years. Following the processes of alignment and leveling, a second CBCT scan was carried out in order to assess and compare the incisor-related changes in alveolar bone from the two groups and concluded that in extraction cases, the palatal side saw a greater amount of vertical bone loss than the labial side following alignment and leveling, according to the study. Alveolar bone loss did not differ

significantly between those that had extraction and those that did not. so in, order to avoid severe loss of alveolar and vertical bone, careful planning is necessary for major movement of the anterior teeth. It is advised to undergo long-term assessments to validate resorption trends and guarantee efficient maintenance of periodontal health.

Declaration by Authors

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Conflict of Interest: The authors declare no conflict of interest.

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