EGYPTIAN
DENTAL JOURNAL

Vol. 66, 747:757, April, 2020

Print ISSN 0070-9484 • Online ISSN 2090-2360

Orthodontics, Pediatric and Preventive Dentistry

www.eda-egypt.org • Codex : 77/2004 • DOI : 10.21608/edj.2020.23973.1035

ALVEOLAR BONE CHANGES AFTER ORTHODONTIC TOOTH MOVEMENTS: A CBCT STUDY

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ABSTRACT

Objective: To determine the changes of the alveolar bone level following intrusion and extrusion orthodontic movement of mandibular incisors.

Material and methods: Twenty patients were divided into two groups; (I): extrusion group and (II): intrusion group pretreatment and post-treatment CBCT and measurements of alveolar bone level in all aspects of the mandibular incisors by Mimics software were done. The obtained data were statistically analyzed.

Results: In group (I), the mandibular lateral incisors showed greater but still statistically non-significant ($P > 0.05$) alveolar bone loss than mandibular central incisors. The lingual aspect of the mandibular lateral incisors showed greater and statistically significant loss ($P < 0.05$) than the same aspect of the mandibular central incisor (0.70 ± 0.13-0.60 ± 0.14 respectively). In group (II), there were non-significant alveolar bone changes between mandibular central and lateral incisors. Comparison between the combined sites between group (I) and (II) revealed that, there was a significant greater loss ($P < 0.05$) in the mesial side of the central incisors in extrusion group than in intrusion group (1.26 ± 0.29-1.12 ± 0.12 respectively), while a more significant loss in the buccal and lingual side of central incisors in group (II) than group (I). The decrease of the alveolar bone level of lower lateral incisors was significantly greater in the distal side of extrusion group than intrusion group.

Conclusions: The mandibular lateral incisors when compared with mandibular central incisors showed a greater amount of bone loss related to lower lateral incisor particularly the lingual aspect. Greater bone loss of the buccal and lingual aspects of mandibular central incisors in group (II) than in group (I)

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INTRODUCTION

The successful treatment of malocclusion is so dependent upon the reaction of bony tissue that the orthodontist must be thoroughly familiar with its physical properties, its histology and anatomy. The alveolar process, because of its relationship to the root of the teeth, certainly merits consideration, especially from orthodontists who use appliances capable of producing bodily movements of the teeth[(1)]. Orthodontic teeth movement must be efficient with minimal iatrogenic effects on teeth and alveolar bone as much as possible [(2-3)]. Orthodontic treatment could influence alveolar bone height. The longer the treatment, the bigger the loss of the top of the alveolar bone it will be. The orthodontic treatment not only will cause resorption in teeth roots but also cause height reduction of the top of the alveolar bone [4].

Yee et al.,[(5,6)] stated that; the alveolar bone did not affected if the applied force kept minimal and light which will resulted in displacement of tooth, alveolar bone and cortical bone, so light force application is considered a principle of tooth movement in any direction .

Evaluation of the alveolar bone height can be assisted by periapical or bite wing x ray film, which possess several disadvantages as distortion, difficult to standardize, variations in angulations. [(7-9)]

Cephalometric x-ray as a two-dimensional view when traced can produce large differences than actual size. [(10-14)] while (CBCT) as a Three-dimensional image have several advantage over 2D image and CT as, excellent contrast, lower cost, low radiation and elimination of overlapping.[(15-19)]

Also (CBCT) due to its minimal distortion thus allowing accurate measures of bone changes than digital subtraction which make it useful for assessment of alveolar bone changes (height and thickness) over time with greater accuracy.[(20-23)] Moreover, CBCT can be transferred into digital (DICOM) format files then with the aid of computer- software a reconstruction of 3D models of the craniofacial skeleton can be done including the teeth and soft tissues.[(24)]

Varghese S et al 2010[(25)] reported conflicting results when compared the computer aided reconstruction programs with two dimensional cephalometric

Recently, 3D cepalometric become popular in orthodontic for reconstruction of 3D image from CT data via the use of Mimics software (Materialise Interactive Medical Imag Control System (Leuven, Belgium). [(26)]

Misch et al.,[(27)] measured periodontal defects with peri-apical film and periodontal probe and compared it with CBCT. They concluded that CBCT offers better capability and accuracy over traditional methods.

Castro et al., [(28)] by the use of CBCT evaluated the changes of the distance between cement-enamel junction (CEJ) relative to the crest of the alveolar bone before and after treatment in non-extraction treatment protocol and reported its increase by 8% on the other hand Lund et al., [(29)] measured the same distance in four premolars extraction protocol and reported its increase by more than 2mm in the lingual aspect of the mandibular central and lateral.

Few studies have used CBCT to evaluate changes in the alveolar bone level after incisor intrusion. [(30,31)] So, this study was designed to evaluate and compare the changes of the alveolar bone level after intrusion and extrusion of lower incisors.

MATERIAL AND METHODS

This study was carried out on 20 patients divided into two groups: 10 patients in each. All need intrusion or extrusion as apart of orthodontic treatment plan. *The criteria of selection*: absence of any systemic disease that may affecting bone, no history of trauma or accident, absence of any previous orthodontic treatment, no history of taking any medications within 6 months before treatment, absence of severe crowding in mandibular incisors region, healthy gingival tissue with no signs of inflammation, probing depths less than 3 mm, absence of any alveolar bone defect or loss.

Fig. (1A): Deep bite indicated for lower anteriors intrusion(intra-oral photograph)

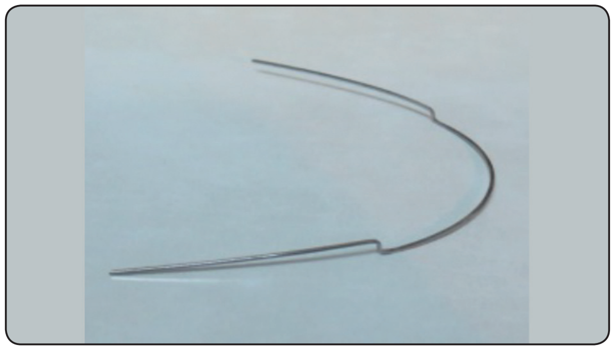

Fig. (1B):16/22 stainless steel arch wire with one mm step down

Fig. (1C): Intrusive arch not engaged in bracket slot

Fig. (1D): Intrusive arch after bracket engagement

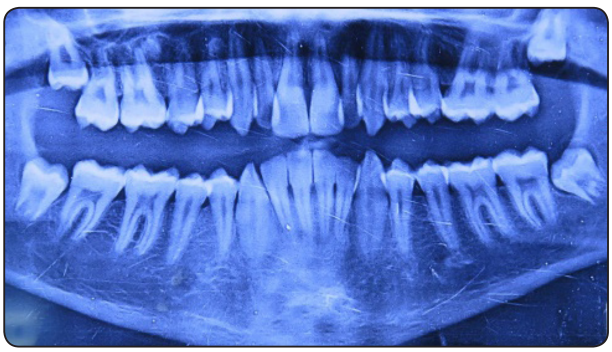

Fig. (1E): Deep bite indicated for lower anteriors intrusion (panoramic x-ray)

Fig. (1F): After 6 months of lower anteriors intrusion (panoramic x-ray)

Fig. (1G): Deep bite indicated for lower anteriors intrusion

Fig. (1H): After 6 months of lower anteriors intrusion

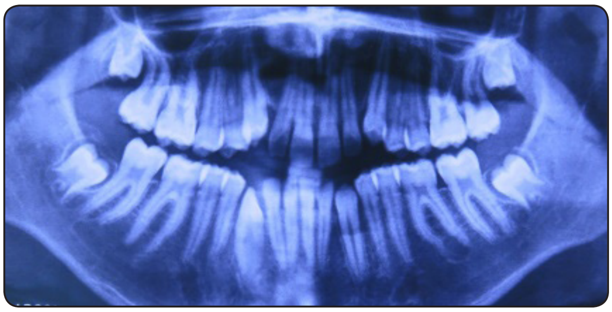

Fig. (2A): lower anteriors indicated for extrusion

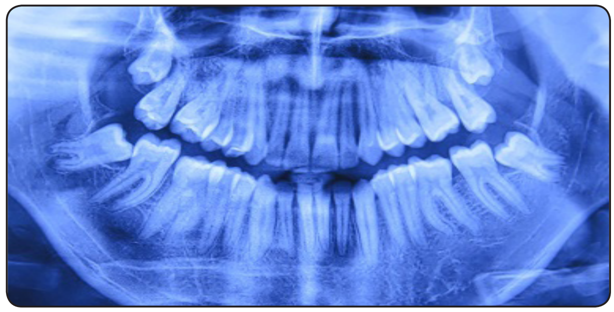

Fig.(2B): after 6 months of lower anteriors extrusion

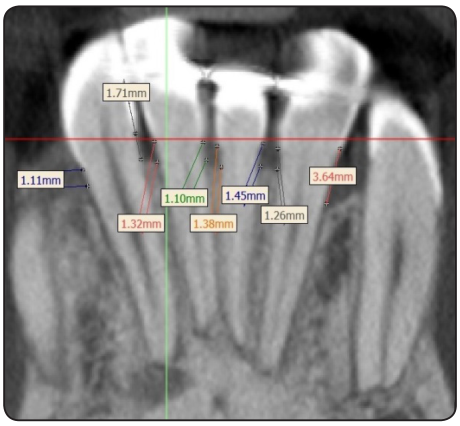

Fig. (3) mesial and distal

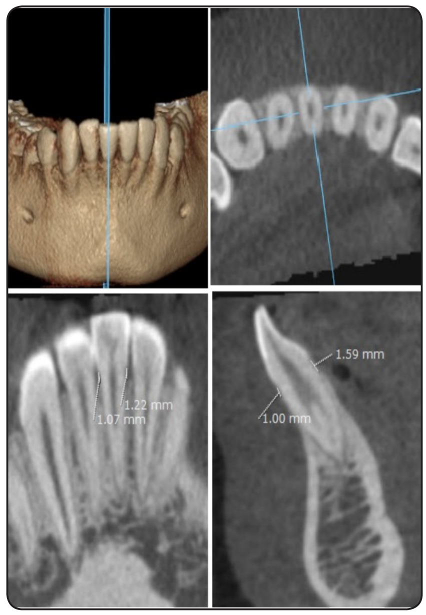

Fig. (4) mesiodistal and buccolingual measurements of lower right central incisor

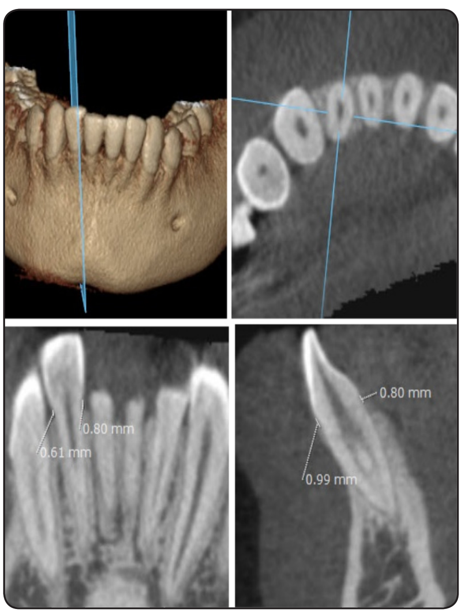

Fig. (5): mesiodistal and buccolingual measurements of lower right lateral incisor

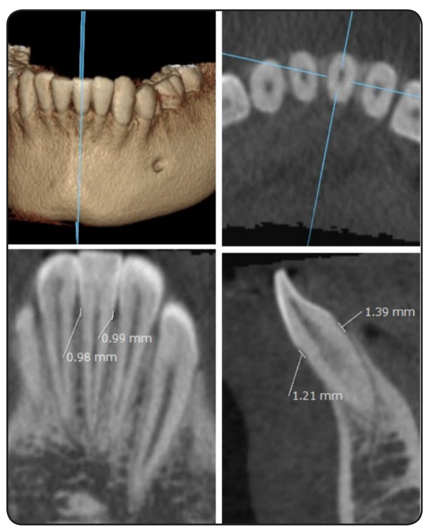

Fig. (6): mesiodistal and buccolingual measurements of lower left central incisor

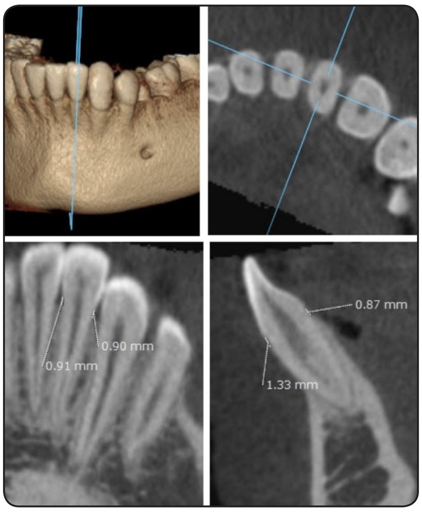

Fig. (7): mesiodistal and buccolingual measurements of lower left lateral incisor

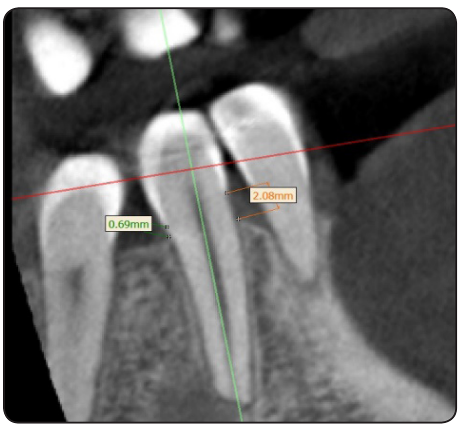

Fig.(8): mesial and distal measurements after extrusion

Fig. (9): mesial and distal measurements after intrusion

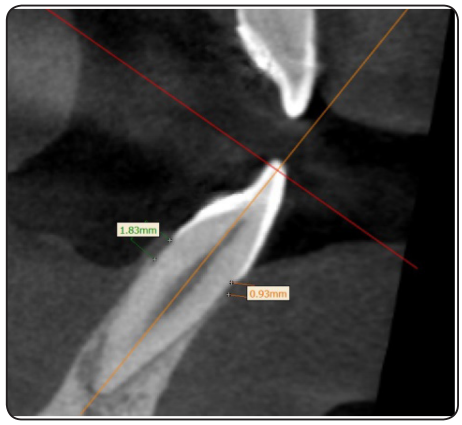

Fig.(10): buccal and lingual measurements after extrusion

Fig. (11): buccal and lingual measurements after intrusion

The appliance of choice was edgewise appliance with 0.022-inch prescription. Initial leveling and alignment were achieved until 16/22 stainless steel arch wire. The intrusive or extrusive arch is 16/22 stainless steel arch wire with one mm step up or step down that delivered a force equal to 40 grams as measured by tension gauge and kept for 6 months. A CBCT was taken just before the insertion of the intrusive or extrusive arch (T1) and after 6 months of force application (T2). By the use of Mimics software the distance between the alveolar bone crest and the CEJ is measured (mesial, distal, buccal and lingual) (figure1A,B,C,D,E,F,G,H & figure 2A, B& figure 3-11) and the obtained data were statistically analyzed using paired t-test with level of significance ($P < 0.05$)

RESULTS

Regarding the extrusion group the alveolar bone moves with the direction of tooth movement; after orthodontic tooth extrusion the alveolar bone level changed by a percentage of 3/4 of the extrusion distance which considered non-statistically significant. The mandibular lateral incisors when compared with mandibular central incisors showed a greater amount of bone loss which still statistically non-significant (P >0.05) in mesial, distal and labial tooth aspects. The only aspect showed a statistically significantly bone loss was the lingual aspect of the mandibular lateral incisors when compared with the mandibular central incisors. (P < 0.05) (Table 1 & Figure 12).

TABLE (1) Extrusion group: Average alveolar bone loss in different aspects of mandibular central and lateral incisors.

Tooth	Central	Lateral	t-test	
	Mean ± SD	Mean ± SD	t-value	p-value
Mesial	1.26±0.293	1.27±0.365	-0.072	0.943
Distal	1.47±0.279	1.57±0.284	-1.176	0.247
Buccal	0.53±0.138	0.64±0.187	-2.019	0.051
Lingual	0.60±0.144	0.70±0.13	-2.306	0.027*

P < .05

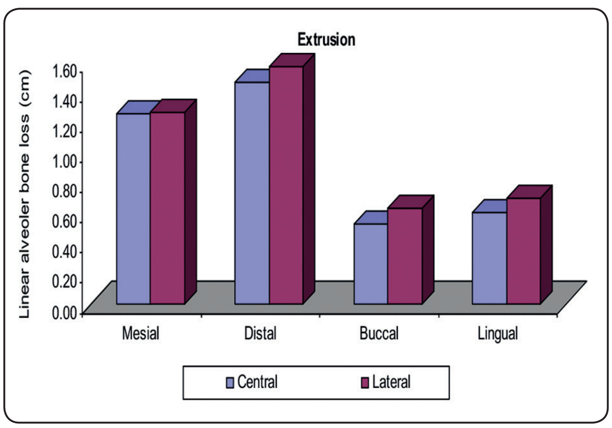

Fig. (12) Extrusion group: Average alveolar bone loss in different aspects of mandibular central and lateral incisors.

Alveolar bone loss after orthodontic intrusion showed a non-significant changes in all aspects when the mandibular central and lateral incisors were compared which was varied from one tooth aspect to the other with an average of alveolar loss 1 mm for every 4 mm intrusion. (P >0.05) (Table 2 & Figure 13).

TABLE (2) Intrusion group: Average alveolar bone loss in different aspects of mandibular central and lateral incisors.

Tooth	Central	Lateral	t-test	
	Mean ± SD	Mean ± SD	t-value	p-value
Mesial	1.12±0.123	1.13±0.226	-0.173	0.863
Distal	1.40±0.266	1.36±0.204	0.467	0.643
Buccal	0.66±0.175	0.61±0.165	0.928	0.359
Lingual	0.74±0.215	0.67±0.144	1.121	0.269

P < .05

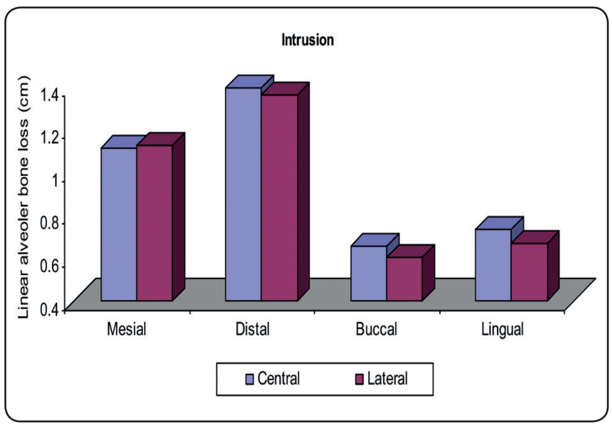

Fig. (13) Intrusion group: Average alveolar bone loss in different aspects of mandibular central and lateral incisors.

When extrusion or intrusion groups were compared a statistically non-significant difference was found in all aspects with greater bone loss of the buccal and lingual sides of mandibular incisors in the intrusion group than in extrusion group. (P >0.05) (Table 3 & Figure 14).

TABLE (3) Mean alveolar bone loss in extrusion and intrusion groups.

Tooth	Extrusion	Intrusion	t-test	
	Mean ± SD	Mean ± SD	t-value	p-value
Mesial	1.26 ±.33	1.12 ±.18	2.438	.017
Distal	1.52 ±.28	1.38 ±.23	2.405	.019
Buccal	0.58 ±.17	0.63 ±.17	1.246	.216
Lingual	0.65 ±.14	0.70 ±.18	1.352	.180

P < .05

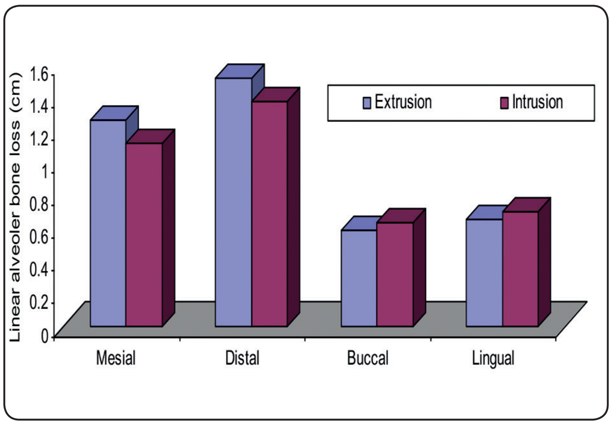

Fig. (14) Mean alveolar bone loss in extrusion and intrusion groups

Comparison of the combined sites of alveolar loss in (mesial, distal, buccal, and lingual) sides of mandibular central incisors between extrusion and intrusion groups revealed that, there was a significant greater alveolar bone loss in the mesial side of the central incisors in extrusion group than in intrusion group. While there was significant more bone loss in the buccal and lingual sides in the intrusion group than extrusion group. (Table 4 & Figure 15).

Regarding to mandibular lateral incisors, there was a non-significant bone loss in the mesial, buccal, and lingual sides between both groups. However, alveolar loss was significantly greater in the distal side of extrusion group than intrusion group (Table 5 & Figure 16).

TABLE (4) Comparison of average crestal bone loss related to mandibular central incisors between extrusion and intrusion groups.

Tooth	Extrusion	Intrusion	t-test	
	Mean ± SD	Mean ± SD	t-value	p-value
Central (Mesial)	1.26 ± 0.29	1.12 ± 0.12	2.043	0.048*
Central (Distal)	1.47 ± 0.28	1.40 ± 0.27	0.810	0.423
Central (Buccal)	0.53 ± 0.14	0.66 ± 0.18	- 2.505	0.017*
Central Lingual	0.60 ± 0.14	0.74 ± 0.22	-2.289	0.028*

P < .05

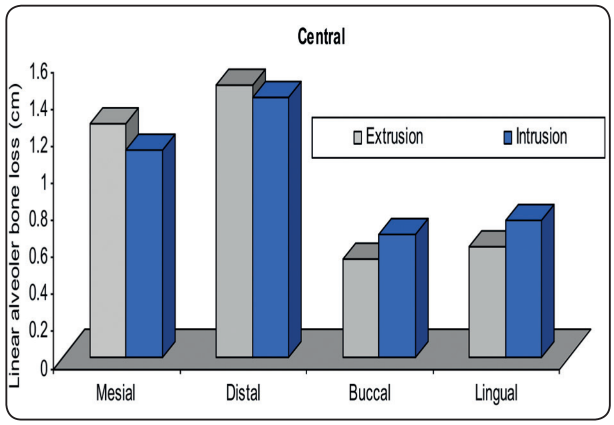

Fig. (15) Comparison of average crestal bone loss related to mandibular central incisors between extrusion and intrusion groups.

TABLE (5) Comparison of average crestal bone loss related to mandibular lateral incisors between extrusion and intrusion groups.

Tooth	Extrusion	Intrusion	t-test	
	Mean ± SD	Mean ± SD	t-value	p-value
Lateral Mesial	1.27 ± 0.37	1.13 ± 0.23	1.483	0.146
Lateral Distal	1.57 ± 0.28	1.36 ± 0.20	2.680	0.011*
Lateral Buccal	0.64 ± 0.19	0.61 ± 0.17	0.537	0.594
Lateral Lingual	0.70 ± 0.13	0.67 ± 0.14	0.747	0.460

P < .05

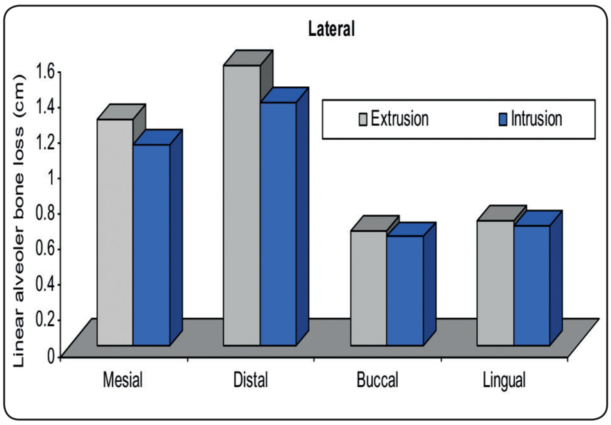

Fig. (16) Comparison of average crestal bone loss related to mandibular lateral incisors between extrusion and intrusion groups.

DISCUSSION

Healthy supporting alveolar bone and periodontal ligament with least undesirable iatrogenic effects is considered a primary a factors to be consider in orthodontic treatment.[31]

Cephalometric or panoramic-like views can be obtained from CBCT with precise identification thus eliminating the need for several radiation exposures.[32] From the constructed 3D model linear, angular, height, width and volume can be measured.[33,34]

As reported by some studies [35,36]), both manual and digital measurements are reliable, while other studies concluded that, 3D scanning technology as Mimics software is more precise and reliable compared with the traditional manual method.[37]

As stated by numerous previous studies, CBCT is considered a highly accurate method used in measuring of alveolar bone dimensions[23,38], so the present study used CBCT and Mimics software to evaluate the alveolar height after orthodontic intrusion and extrusion.

The effect of orthodontic treatment on the surrounding alveolar bone that can be measured radiographically still a matter of debate.[4] Bondemark [39] conducted a study on the changes in distance of CEJ and the crest of alveolar bone after orthodontic treatment for 5 years and found that; the average changes ranged from 0,7mm to1, 0 mm

In the current study, it was observed that, in the extrusion group, alveolar bone loss was increased in the lingual side of mandibular central and lateral incisors (0.60 ± 0.144, 0.70 ± 0.13) respectively, than in the buccal side (0.53 ± 0.138, 0.64 ± 0.187). These results are in consistent with that of Kim et al., 2009 [40] who stated that the symphysial alveolar bone was developmentally thinner so alveolar bone loss occur in the mandibular anteriors following orthodontic teeth movement.

Also, Szulc P 2000 [41] explained the greater alveolar bone loss in the lingual side more than in the buccal side in children than adults due to higher bone turnover rate. Similarly, Thongudomporna U 2015 [6] considered bone remodeling in children is rapid with apposition more than resorption thus maintaining labial alveolar bone thickness and the more labial tipping of the incisors the greater the alveolar bone loss apico-palatally this conclusion was the opposite of Lee et al.,2012 [20] who found non-significant correlation between alveolar bone loss and labial incisor tipping.

Korayem et al.,2008 [42] In contrast with the result of the present study concluded that ;orthodontic extrusion with light force can add crestal alveolar bone in vertical and bucco-lingual directions only in the occusal third not in the middle or apical third of the root. On the other hand Thongudomporna et al.,2015 [6] reported that ;during orthodontic extrusion with higher rate the tooth entered a narrower alveolar bone housing and bone remodeling could not follow this high rate of extrusion.

There was significant increase of bone loss in both buccal and lingual sides of mandibular central incisors in intrusion group than in extrusion group. These results were inconsistent with that of Atik et al.,2018 [31] who reported that, the rate of alveolar loss was relatively higher in labial aspect than lingual;this differences may be due to different biomechanics, different force levels, and individual variation.

The present study revealed that, there is bone loss in mesial, distal, buccal, and lingual sides of mandibular central and lateral incisors after intrusion movement. This finding came in accordance with Erkan et al., 2007 [43], Cao et al., 2015 [44] and Zoizner et al.,2018 [45] who reported that, the dento-gingival complex moved in the same direction of the teeth movement thus infra-bony pockets and vertical bone defects were minimized..

In the present study, by comparing alveolar loss between central and lateral incisors in both groups, it was found that, regarding to mandibular central incisors, there was more bone loss on the buccal and lingual side in intrusion group than in extrusion group. While there were more interproximal bone loss after extrusion than intrusion. On the other hand, it was found that, there was greater bone loss related to all sides of extruded mandibular lateral incisors than in intruded ones. These results were matched with those of Bellamy, 2008 [46] and Altamirano NE 2017 [47] who reported that; intrusion of healthy mandibular incisors with light continuous force in adult patients lead to minimal alveolar bone loss and elimination of periodontal pocket.

Some studies came in contrast with the present study mainly due to the force magnitude and method of measurement as Castro et al., 2016 [28] reported that the distance between CEJ and crest of the alveolar bone did not change by orthodontic movement. While Miyama et al. 2018 [48] reported decrease in the distance between CEJ and alveolar bone crest after intrusion or extrusion. Some animal studies found that; the changes in alveolar bone after extrusion of upper incisors of monkey equal to 80% of the extent of tooth movement and in intrusion cases, similar to the degree of tooth movement. [49-52]

In the current study, patients in extrusion group showed increase interproximal bone loss of mandibular incisors than those in intrusion group with greater alveolar loss on the distal sides compared to the mesial sides in both groups which may be due to distalization of teeth during orthodontic treatment. These finding were supported by Ahuja et al., 2009[53] who reported a significantly higher alveolar loss in distal aspect than mesial aspect.

Alveolar loss was significantly increased in mesial aspect of extruded mandibular central incisors than in the intruded ones. While the mandibular lateral incisors showed a significantly increased bone loss in the distal side after extrusion than after intrusion. This variations may be due to anatomical variations as crown root ratios, dimensions of tooth and periodontal ligament space. so Further studies that involve full set of teeth are required over the total treatment time even after the end of orthodontic treatment

CONCLUSION

- Mimics software program can be used effectively for 3D measurements of the alveolar bone level.
- The relationship between CEJ and the crest of alveolar bone was maintained to some extent mainly during extrusion.
- More proximal alveolar bone loss specially distal than buccal or lingual.

It is recommended to follow up the changes in the alveolar bone 1 year after completion of the orthodontic treatment.

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