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ORIGINAL RESEARCH

IMPACT OF ORTHODONTIC TREATMENT ON ALVEOLAR BONE THICKNESS USING CBCTS: A META ANALYSIS

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ABSTRACT

Orthodontic treatment ensures genuine arrangement of teeth, and also improves the occlusal and jaw relationship. Like other treatment modalities, orthodontic treatment, despite its points of benefits, has related perils and complexities as well. In any case, the danger and intricacy related with treatment are represented to be widely lower diverged from other cautious or nonsurgical interventions.

AIM: To survey challenges in alveolar bone thickness around the orthodontically treated teeth estimated with CBCT.

MATERIALS AND METHODS: An electronic hunt was directed in PubMed, Scopus, Embase and Cochrane Library, utilizing search terms, with no restriction on distribution date, up to July 2020. The articles chose for examination included randomized controlled trials, case-control studies and cohort investigations of patients treated with fixed orthodontic appliance, which had estimated alveolar bone thickness with CBCT when treated.

RESULTS: Out of 150 articles, only 50 were related to the subject. After proper title and abstract reading, only 9 articles were found to be fit for the meta-analysis. All the articles were found to be of medium quality with the change in alveolar bone thickness around cervical third in labial portion of the teeth, presenting increases of 0.4-0.64 mm with considerable results on the palatal sides.

CONCLUSION: On patients experiencing diverse orthodontic treatment strategies, there was a noteworthy decrease in bone thickness, for the most part on the palatal side. These findings were significant and must be considered in determination and arranging of tooth development, so as to forestall the event of dehiscence and fenestration in alveolar bone.

KEY WORDS: Alveolar Bone Thickness, CBCT, Orthodontic Treatment, Thickness

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INTRODUCTION:

Although orthodontic treatment with fixed appliances has become an essential piece of contemporary orthodontics, it has additionally been related with certain unfriendly impacts including root resorption, development of white spot, and/or periodontal ramifications, including alveolar bone loss and clinical attachment loss.[1-3]

Orthodontic fixed apparatuses make support of legitimate oral cleanliness increasingly troublesome, bringing about expanded plaque accumulation and resulting in mild inflammation of the oral tissues. It has been archived that fixed machines have a critical effect on both microbial and clinical intraoral conditions[4], which can vary from patient-patient, site-site, and appliance specific characteristics[5,6] and is for the most part observed as increased probing depth, increased bleeding on probing, increased crevicular fluid volume, and a shift from aerobic to anaerobic microbial species[4,5]. It is anyway accepted that these treatment-actuated changes are for the most part transient[7], are standardized in any event mostly after removal of the orthodontic appliance[8], and are not related with any enduring hindering impact on the encompassing periodontal tissues[7]. A past methodical audit on this point showed that orthodontic treatment has little, yet factually huge, negative impacts to the periodontium, as far as alveolar bone loss, gingival recession, and periodontal pocket formation1 is concern. Notwithstanding, longitudinal estimations of clinical attachment levels remain the best quality level to measure change in the periodontal status of patients[9] and are viewed as a proportion of past disease activity, and hence an increasingly precise proportion of history of infection and disease progression than pocket probing depth.[10,11]

MATERIAL AND METHODOLOGY:

SEARCH STRATEGY:

A precise survey of the reference index was led as per PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) proposals[12]. Searches were made in the PubMed, Scopus, Embase and, Cochrane Library databases, utilizing a similar pursuit terms in each, with no impediment on distribution date, up to and including 15th July 2020.

The catchphrases utilized in the database search through consolidated terms (including MeSH and non-MeSH terms) with Boolean administrators (and/or) additionally. The pursuit utilized the terms such as alveolar bone thickness/density and orthodontic treatment. Furthermore, CBCT, trailed by alveolar bone thickness or tooth development and CBCT was utilized.

INCLUSION CRITERIA:

The survey acknowledged articles in any language. Randomized controlled trials, case-control studies, and cohort studies were incorporated, as were both retrospective and prospective examinations. The incorporation criteria were articles exploring patients in permanent dentition treated with fixed appliances, which experienced extractions and who encountered incisor retractions.

A further rule was the accessibility of CBCT checks estimating alveolar bone thickness on the labial and, palatal sides of the teeth both prior and after treatment. The determination of articles was made on the basis of titles and abstracts, the reviewers read the full articles and recorded the reasons for approval and dismissing of any article.

EXCLUSION CRITERIA:

Systematic reviews, meta-analysis, case reports, case series, literature reviews and editorials were excluded. Articles that included patients treated with orthognathic surgical procedure or patients with congenital disorders and additionally any systemic disease were not included.

EXTRACTION OF DATA AND ANALYSIS OF THE VARIABLES:

The variables analyzed in each article included the type of study, sample size, demographic feature (sex, age), follow-up time, CBCT used, results obtained, and conclusion (Table 1).

Table 1: variable analysis

Authors	Year	Type Of Study	N (M/F)	Mean Age (Years)	Follow Up Time	CBCT used	Conclusion
Sarikaya *et al*[17]	2002	retrospective	19	14.1 ± 2.3	T1: pre-treatment	Tomoscan SR7000: Philips, Best, the Netherlands.	On the labial side, there have been no noteworthy

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					T2: 3 months post-retraction	(120kV, 175 mA, with a window width set a 5000, 1500HU).	changes in bone thickness. On the palatal side, a decrease in bone thickness was seen in S1 and S2.
Ahn *et al*[18]	2013	retrospective	37 (0/37)	26.6±8.5	1.8±0.4	Implagraphy, Vatech, Seoul Korea (12x9cm FOV, 90kV, 4.0 mA, 0.2 mm isotropic voxel, 24 sec output time)	The alveolar bone thickness of all the maxillary incisors fell fundamentally.
Picanço *et al*[19]	2013	retrospective	12 (6/6)	G1: 6 (1/5) 15.83 ± 4.87 G2: 6(5/1) 18.26 ± 6.42	G1: 2.53 ± 0.49 G2: 2.39 ± 0.66	Not specified	No adjustments in alveolar bone thickness happened aside from inside vestibular S3 of the maxillary incisors in bunch G1, where the thickness reduced.
Nayak Krishna *et al*[20]	2013	retrospective	10(0/10)	15 ± 3	T1: pre-treatment T2: 3 months post-retraction	GE clinical frameworks (120 kV, 160MVA, with window width set at 2444 level 364 from spiral CT)	The adjustments in alveolar bone thickness on the labial side weren't huge. On the palatal side, the progressions were huge in S1 and S3.
Yodthong *et al*[21]	2013	retrospective	23 (2/21)	20.4 ± 2.7	T0: pre-retraction T1: 6 months post-retraction Follow-up time: 12 months	Veraviewepocs J Morita MPG (80 x 40 mm FOV, 80kV, 5 mA, 0.125 mm voxel, 7.5 second exposure time).	Labial alveolar bone thickness in S3 and all out alveolar bone thickness in S1 both expanded fundamentally.
Almeida et al[22]	2015	Randomized controlled trial	25	18.58 ± 5.43 (test)21.61 ± 6.69 (control)	-	I-CAT Imaging Sciences 50 International, 22x16-cm field of view, 120 kVp, 36 mA, 0.4-mm voxel size and 40-second sweep time.	There was critical lessening in mandibular buccal bone thickness and cross-over width of buccal bone in the two gatherings.
Thongudomporn et al[23]	2015 50	Case series	15(4/11)	9.9 ± 1.0 years	-	Veraviewepocs J Morita MPG, 80 kV, 5 mA, 7.5 second presentation time, 0.125 mm voxel goal, 80 x 40 mm field of view.	Changes in labial bone thickness at all levels weren't not critical.
Jian-Hong Yu et al[24]	2016	observational	8	20-25	T0:before the orthodontic treatment	120 kVp, 47 mA, 250-mm voxel goal, and 16-cm field-of-view.	the distinction somewhere in the range of T0 and T1revealed 23.36% decrease in bone thickness, while the

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					T1: at the end of 7 months of active orthodontic treatment T3: after several months (20–24 months) of retention T2.		distinction somewhere in the range of T1 and T2 indicated a 31.81% expansion in bone thickness. The distinction somewhere in the range of T0 and T2 (when treatment) affirmed that the bone thickness generally stayed steady however, the bone thickness around 11% of the teeth didn't recuperate to just 80% of its unique state.
Fabian Jäger et al[25]	2017	Retrospective	43(24/19)	25±5	-	I-CAT Next Generation (Imaging Sciences International, Hatfield, Pa), with a field of perspective on 13 × 16 cm and a picture goal of 0.25-mm voxel size.	90% of patients more youthful than 30 demonstrated decreased bone stature of least one tooth.

QUALITY APPRAISAL:

The nature of the articles was classified using CONSORT measures as adjusted by Mattos et al. in 2011[13], which have been utilized by a few authors in various systematic reviwes[14-16]. This meta-analysis used CONSORT criteria as for assessing the quality of the methodology, design, execution and examination of each article and arranging them into three levels: low, medium or high quality (Table 2 and Fig 2).

TABLE 2: Representing quality appraisal.

Authors	Blind	Control Group	Inclusion/Exclusion	Statistics	Follow Up	Dropouts	Limitations	Total
Sarikaya *et al*[17]	0	0 0	0.5 0	1	1 0	0 0	1 1	3.5 1
Ahn *et al*[18]	0	0	0.5	1	1	0	1	3.5
Picanço *et al*[19]	0	1	1	1	1	0	1	5
Nayak Krishna *et al*[20]	0	0	0.5	1	1	0	1	3.5
Yodthong *et al*[21]	0	0	1	1	1	0	1	4
Almeida et al[22]	0	0	1	1	0	0	1	3
Thongudomporn et al[23]	0	0	1	1	0	0	1	3
Jian-Hong Yu et al[24]	0	0	0.5	1	1	0	1	3.5
Fabian Jäger et al[25]	0	0	1	1	0	0	1	3

3.5

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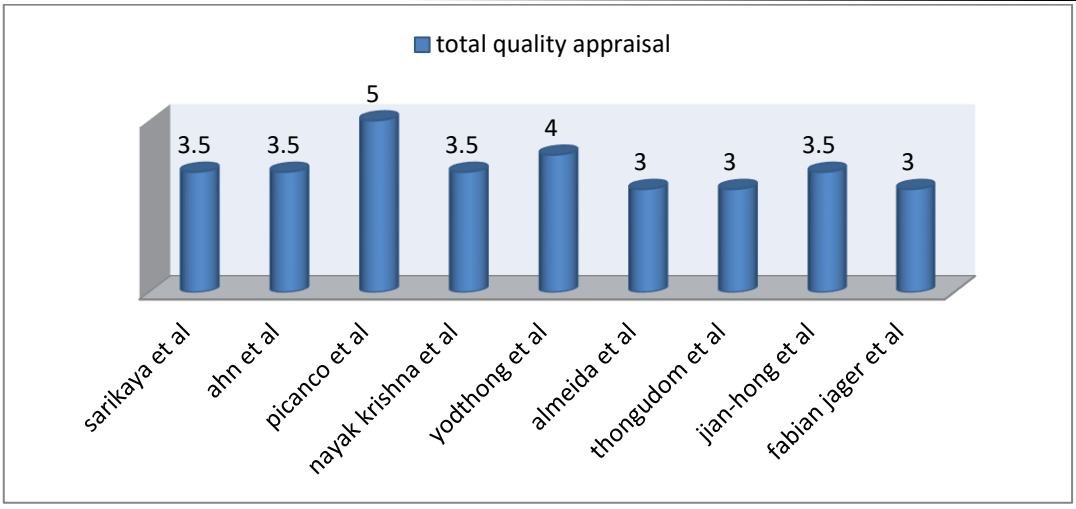

Fig 1: Representing the quality appraisal of the articles

RESULTS:

SELECTION OF ARTICLES:

The underlying database search distinguished 150 articles: 50 in Pubmed, 48 in Embase, 42 in Scopus, and 10 in the Cochrane Library. Of these, 100 were found to possess similar content, leaving 50. At the point when the titles and abstracts were read, only 9 articles were found to be fit for the meta-analysis and rest of 41 articles were dismissed because they didn't meet the consideration measures (Fig: 2).

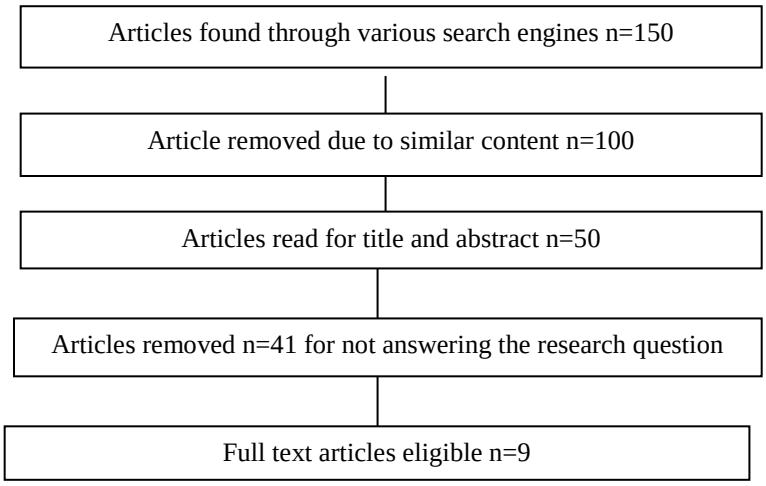

Fig 2: PRISMA flow chart. Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analysis: The PRISMA Statement.[26]

QUALITATIVE ANALYSIS:

Each article was reviewed and was found to be of moderate quality as per the rules proposed by Mattos et al[13]. Four concerned Angle class I patients with twofold distension who experienced extraction of the four first premolars, while the rest of the work considered class II division 1 patients who experienced extraction of the maxillary first premolars[19] and one with class III division[23]. The principle controlled assessment was by Picanço et al., who treated case gathering of class II by extractions of the maxillary first molars with a benchmark group of patients who were treated without extractions.[19] As far as the time between CBCT scans, Yodthong et al. performed an initial CBCT (T0) and a final CBCT (T1) a half year after withdrawal of the incisors.[21] Ahn et al. performed out the last CBCT after space closure, without indicating the time[18] Sariyaka et al[17] and, Nayak et al[20] performed the last CT three months after incisor withdrawal while Picanco[19] et al. performed out the final CBCT check subsequent to completion orthodontic treatment, year and a half after the underlying CBCT check. Almeida et al[22] performed CBCT 7 months after treatment onset (T2) while in Jian-Hong Yu et al[24] study each patient underwent 3 dental CBCT scans:

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before treatment (T0); at the end of 7 months of active orthodontic treatment (T1); after several months (20–22 months) of retention (T2) and Fabian Jager et al[25] performed CBCTs in patients with multibracket appliances for at least 1 year.

The teeth where the alveolar bone thickness was estimated were upper incisors and canines18, the four upper incisors[19, 21], or the four upper and lower incisors [17], 20. With respect to techniques utilized, Ahn et al., Sariyaka et al. and, Nayak et al. treated patients with extraction of the first premolars and maximum anchorage[18], while Picanço et al., Jian et al, Fabian et al, Yodthong et al. didn't indicate the kind of anchorage utilized. Yodthong et al. isolated the patients into two sub-groups concurring to their root development, utilizing sliding mechanics in 11 patients and loop closure mechanics in 12 patients. Picanço et al didn't express the space conclusion technique utilized.

The technique used to quantify alveolar bone thickness which was equivalent in all the nine investigations. Labial (Vb) and palatal (Pt) thicknesses were evaluated utilizing CBCT pictures, isolating the root with equivalent lines at 3 mm ranges from the cemento-enamel junctions to the most elevated point. Along these lines, the estimations were made in the cervical, central and, apical thirds and in the full scale tooth underneath the cementoenamel junctions.

Picanço et al.[19] who grouped patients into two, found that in the group that experienced extraction of the maxillary first premolars and in the control group without any extractions, the former group patients demonstrated more retraction of the maxillary incisor and a more vertical position, while the latter patients demonstrated more noteworthy labialization and distension of the incisors. The bone thickness in the labial cervical third was greater in first group than in second group patients. Yodthong et al.[21] found that adjustments in the gathering of patients treated by withdrawal with tipping were more noteworthy in the palatal cervical third of the incisors (r=0.6; p=0.006), while the adjustments in alveolar bone thickness were more negative in the gathering treated by withdrawal with force (r=-0.3; p=0.031).

Sariyaka et al.[17] found that the changes in maxillary labial bone thickness was not factually greater. The width of the bone labial to the maxillary left lateral incisor diminished essentially in the center fragment (S2) ($p<0.05$). As to upper bone thickness lingual to the incisors, the apical section (S3) estimations indicated negligible change, however the estimations at the cervical (S1) and center (S2) section levels contrasted essentially after some time.

Almeida et al[22] found significant mandibular expansion in both the groups with a significant decrease in mandibular buccal bone thickness and transversal width of buccal bone.

Thongudomporn et al[23] although found a statistically significant decreases in palatal and total bone thickness at the S2 and S3 level ($P < .05$), the amounts of these changes were clinically insignificant, ranging from 0.34 to 0.59 mm. Jian-Hong Yu et al[24] used CBCT was used to measure the changes in bone density around 6 teeth in the anterior maxilla before and after orthodontic treatment. Each patient underwent 3 dental CBCT scans and found that, the bone density around 10% of the teeth in anterior region could not recover to 80% of its state from before the orthodontic treatment. Fabian Jäger et al[25] found a combined (facial and lingual) change in bone thickness averaged -0.56 ± 0.7 mm at 5 mm apical to the CEJ, and -0.69 ± 0.9 mm at 10 mm apical to the CEJ. Lingual bone thickness 10 mm apical to the CEJ decreased significantly by an average of -0.4 ± 0.78 mm and was greater than the treatment-related bone thickness decrease observed at other sites.

Ahn et al., Nayak et al., and Picanço et al. discovered a decline in alveolar bone thickness in all the palatal sections of the central incisor, though Yodthong et al. also, Sariyaka et al. simply found more noteworthy reductions in the cervical area on the palatal side of the incisors. On the labial side, Picanço et al. discovered a higher augmentation in bone thickness in the cervical zone and Ahn et al. in the inside piece.

DISCUSSION:

Barely any examinations have researched the utilization of CBCT to enroll the adjustments in alveolar bone thickness around the incisors that happen in cases treated with extractions and, all at once withdrawal of the incisors. One explanation behind this is the moral issue of radiation presentation, as this requires presenting the patient to two radiographic assessments; another is the methodological decent variety between the couple of studies that have been distributed.

Work is in progress to diminish the radiation produced by CBCT machines, the same numbers of the patients analyzed by this strategy are youngsters, who are more susceptible to the impacts of radiation. For this reason, it is imperative to keep up an ideal harmony between the requirement for sufficient picture quality and radiation portion.

In spite of the fact that CBCT scanners can catch an exact 3D picture of the dentoalveolar complex, it is critical

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to choose cases that truly will profit by CBCT assessment also, to survey marginal cases cautiously. These cases incorporate alveolar bone phenotypes that are clinically as well restricted to oblige labio-lingual displacements, patients with periodontal diseases, cases that require tooth development past as far as possible, including impacted teeth that require a choice with respect to whether to extract or not.[27]

Fuhrmann et al.[28] demonstrated that quantitative evaluation of alveolar cortical bone utilizing computerized tomography (CT) is practical over a base bone thickness of 0.5 mm and acquired outcomes that were factually like histological estimations. Various authors have discovered that palatal development of the incisors limits the alveolar bone on the palatal side[17,20]. Few authors have even discovered a 1 mm decrease in alveolar bone thickness between pre-treatment and post-treatment estimations[20].

As per Handelman, bone loss can be impacted by treatment including extractions and the measure of force utilized in orthodontic movement. Dehiscence also, fenestration are two delayed consequences that can happen at the point when incisors are retruded; distension of the maxillary incisors can prompt dehiscence of the alveolar cortical bone on the labial side, while withdrawal influences it on the palatal side29. Picanço et al.[19] got huge difference in bone thickness between the two groups in the labial cervical third, which expanded by 0.67 mm in G1 yet diminished by 0.06 mm in G2. There was no understanding between the investigations as respects the planning of the final CBCT check. Ahn et al. performed the scans once space closure had occurred; Picanço et al. toward the finish of orthodontic treatment, around year and a half after the underlying closure.

These distinctions could prompt contrasts at long last results, as certain authors, for example, Vardimon et al.[30], have contended that the cortical plate of alveolar bone can experience rebuilding during treatment, changing its shape also, position. This stands out from the speculation put forward by Handelman, who contended that there are constraints on tooth development brought about by the cortical plates and, indicated that bone rebuilding is conceivable during tooth development, instigated by organic powers[29].

Dentoalveolar anatomy builds up the restrictions of orthodontic tooth movement, and the bone's ability for adjustment during tooth development, just as its morphology when the teeth have arrived at their last position[27]. As we would like to think, deciding if bone goes with teeth during withdrawal and whether the bone is equipped for redesigning or not legitimizes utilizing CBCT both before and after orthodontic treatment. The results indicated that palatal development of the maxillary incisors lessened the palatal alveolar bone. This finding can't resist repudiating De Angelis, who ensured that alveolar bone has a bowing limit.[31] In the current examination, the maxillary bone thickness didn't remain the proportional anyway reduced.

LIMITATIONS:

Further examinations are required with controlled and blind investigations to study cases from the beginning of treatment and look for the changes in the bone before and after treatment. The current study possessed a few constraints as the sample size in every study is small; there is shift in methods used to measure the bone thickness.

CONCLUSION:

Regardless of the methodological variances between the investigations studied, it might be expressed that a noteworthy increment in alveolar bone thickness happens in the cervical third on the labial side of the central incisor after orthodontic treatment around 0.4-0.64 mm.

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