Assessment of alveolar bone thickness buccal to maxillary anterior and premolar teeth in a sample of Egyptian population using CBCT: An Observational Cross-Sectional Study

September, 6th, 2020.

By

Menna Mosaad El-said Hassan
B.D.S 2012

Protocol Checklist				
Section and topic	**Item No.**	**Checked item**	**Reported on page No.**	**Reviewer's check**
I. Administrative Information				
	1	Title: PECOS elements included	1	
	2	Protocol Registration	1	
	3	Protocol Version	1	
	4	Funding	1	
	5	Roles and Responsibilities of the Authors	1,2	
II. Introduction				
	6a	Scientific Background	2,3	
	6b	Review of Literature	6,7,8,9	
	6c	Statement of the Problem	10	
III. Methods				
A) Study Design and Settings	7	Study Design	10	
	8	Settings	10	
B) Participants	9a	Eligibility Criteria	11	
	9b	Methods of selection or case/control ascertainment	-	
	9c	Methods of follow up for cohort studies and rationale for choosing cases and controls for case control studies	-	

	10	*Matched cohort study*—matching criteria and allocation ratio (exposed: non-exposed) *Matched case-control study*—matching criteria and allocation ratio (case: control)		
C) Variables	11	Clearly define all variables including outcomes and exposures	12	
	12	For each variable of interest, give data sources/ measurement	12,13	
	13	Addressing potential sources of bias	13	
D) Study Size	14	Study size	14	
E) Quantitative Variables	15	Handling of quantitative variables in the analyses	14	
F) Statistical methods	16	Statistical methods used to control for confounders	14	
IV-Ethics and Dissemination				
	17a	Research ethics approval	15	
	17b	Protocol amendments	15	
	17c	Access to Data	15	
	17d	Dissemination Policy	15	
V- References				
		References by reference manager	16,17,18	

Evidence Based Committee (Reviewers)

Name	Signature	Date
1.		
2.		
Research Plan Committee		
Name	**Signature**	**Date**
1.		
2.		

I-Administrative Information

1-Title: Assessment of alveolar bone thickness buccal to maxillary anterior and premolar teeth using CBCT in a sample of Egyptian population using CBCT: An Observational Cross-Sectional Study

2-Protocol Registration:
Registered at www.clinicaltrials.gov
ID: ……

3-Protocol Version: 1st version

4-Funding: self-funding

5-Roles and responsibilities of the authors:

Principal Investigator: Menna Mosaad EL-said Hassan
Masters degree in Oral and Maxillofacial radiology
Department of Oral and Maxillofacial Radiology
Faculty of Dentistry, Cairo University

Roles of the investigator:

- Preparing the technical proposal.
- Assuring that the design is appropriate to the proposed question.
- Identifying the need for sub-recipient agreements.
- Ensuring that the used procedures are consistent with sound research design and do not unnecessarily expose subjects to risk/harm.
- Being responsible for all required actions to manage and complete the scientific and programmatic aspects of the project (including data collection and assessment).
- Ensuring the integrity and safeguarding of notebooks and scientific data. Ensuring the completion, accuracy and timeliness of programmatic (technical) reports.

Chief Supervisor: Dr. Farid Medhat
Assistant Professor
Department of Oral and Maxillofacial Radiology
Faculty of Dentistry, Cairo University

Roles of Chief Supervisor:

- Assisting the candidate -in association with the co-supervisor -to prepare a full research plan that can be completed and written up within the prescribed period of study, and to seek approval for that proposal.
- Establishing a research plan with the investigator, in which the work is completed.
- Discussing the work done through meetings or exchanging email messages if the candidate is in a remote location, at least once per month. Assisting the candidate by regularly checking the records of data and observations and suggesting improvements where appropriate.
- Providing constructive criticism and advice on submitted written drafts within agreed time frames.
- Supporting the candidate in the preparation for thesis defense.
- Facilitating timely completion of the candidate's study and ultimate completion of the thesis.

Assistant Supervisor: Dr. Arwa Mousa

Lecturer

Department of Oral and Maxillofacial Radiology

Faculty of Dentistry, Cairo University

Roles of Assistant Supervisor:

- Monitoring the progress of the student's research through regular formal supervisory meetings and ensuring that the research student keeps an agreed record of these meetings.
- Being accessible at mutually convenient times when the research student may need advice.
- Performing the blind assessment during the data collection stage.
- Giving detailed advice on the necessary completion dates of successive stages of the work so that the thesis can be submitted within the relevant maximum registration period.
- Reading and commenting on the whole of the final draft of the thesis, provided that this is presented within a reasonable and agreed time frame, and ensuring that the research student is aware that the thesis must comply with all relevant regulations, including those on word length, format, and binding.

II-Introduction

6. a. Scientific Background: Tooth loss in an esthetic area is often undesired experience for the patient. Dental implant offers the most long term solution for missing teeth replacement, replicating the root and crown of the natural tooth. This procedure reserves both the gingival mucosa and the remaining alveolar bone without damage to adjacent teeth ***(Singh et al., 2015)***.

According to the conventional protocol of dental implant, a period of 3-4 months is required for socket healing, followed by implants insertion, then additional 3-4 months are needed for implant integration with surrounding bone. Moreover, one additional step is required to load the prosthetic abutment ***(Singh et al., 2012)***. This conventional protocol consumes extended period of time leaving the patient with missing tooth. Many attempts to shorten the overall length of treatment had focused on approaches of immediate or early implant placement especially in the esthetic zone ***(Bhola et al., 2008)***.

The advantages of the immediate implant placement include, less surgical intervention procedures, so reduction in therapy time, preservation of the bone and gingival tissues, and psychological confidence for the patient. In spite of the advantage of the immediate implant placement, it is still a challenging treatment option for the clinician and presents a higher incidence of complications. ***Gluckman et al., 2018*** reported that the anatomic factors which influence the outcomes of immediate implant placement at the anterior region are the gingival biotype, the thickness and height of the existing alveolar bone, the amount of bone beyond the apex, and the buccal gap.

Following tooth extraction, high degree of resorption is expected, which is more severe in the buccal alveolar wall thickness ***(Wang et al., 2014 and Fuentes et al., 2015)***. In other words, the bone change is more suspected in the buccal alveolar bone and the palatal alveolar bone is less affected area. Also it was reported by ***Ten Heggeler et al., 2011*** that the resorption of the buccal alveolar bone in the anterior are more affected than posterior areas, since the bone resorption is more siginficant where the walls are initially thinner. The vertical and horizontal reduction of bone dimensions is unavoidable ***(Lindhe 2014).*** In the first 3 months after dental extraction**,** this resorption is more noticeable. However, bone remodeling may last for 12 months but less intense, resulting in dimensional change ***(Dos Santos et al., 2019)***. In some opinions, the buccal alveolar

bone thickness should be at least 2 mm to prevent labial gingival recession and to achieve an optimal biologic and esthetic outcome ***(Grunder et al., 2005 and Miyamoto et al., 2011)***.

Hence in most situations, bone augmentation procedure has been recommended with immediate implant placement in the aesthetic zone ***(Wang et al., 2014)***.

Recently, several studies have been published discussing if there is enough thickness in the labial alveolar bone for immediate implant placement in an anterior maxillary region. Nevertheless, the existing studies only include anterior teeth. There is not enough research regarding the premolars although they play a role in the aesthetic region.Therefore, this study is designed to investigate the thickness of the buccal alveolar bone of maxillary anterior and premolar teeth in a sample of Egyptian population using Cone beam computed tomography (CBCT) at different levels that are clinically relevant.

PO question

P: Maxillary anterior and premolar teeth of the adult Egyptians.

O: Alveolar bone thickness buccal to the maxillary anterior teeth and premolars of adult Egyptian population.

	Outcome Measured	**Measuring Device**	**Measuring Unit**
Primary Outcome	Thickness of the buccal alveolar bone of the maxillary centrals.	Linear measurement of Ondemand Software	Millimeters
Secondary Outcomes	Thickness of the buccal alveolar bone of the maxillary laterals, canines and premolar teeth	Linear measurement of Ondemand Software	Millimeters
	Mean difference of the alveolar bone thickness between genders	Linear measurement of Ondemand Software	Millimeters
	Mean difference of the alveolar bone thickness between different age groups	Linear measurement of Ondemand Software	Millimeters

Secondary Outcomes	Prevalence of dehiscence and fenestration in the maxillary anterior and premolar teeth	CBCT images on Ondemand software	Categorical nominal data Percentage (%)

Research question:

What is the average thickness of the alveolar bone buccal to the maxillary anterior and Premolar teeth in the Adult Egyptian population?

6b. Review of literature

List of main databases used in search:

- ✓ Pubmed
- ✓ Google Scholar

Keywords:

Alveolar bone thickness, maxillary anterior teeth, maxillary premolars, CBCT, immediate implant.

Kim et al., 2012 has reported that the restoration of the maxillary anterior region with implant-supported prostheses has been a difficult procedure because of the high aesthetic demand of patients. The aesthetic satisfaction and implant placement can be affected by the soft tissue defect associated with volumetric changes of the alveolar ridge ***(Rodriguez et al., 2012)***.

It was conducted by ***Blanes et al. 2007*** that the proper alveolar bone thickness is essential for the long-term stability of the mucosa around the dental implants. According to the naturally biological events, the maxillary alveolar bone of the anterior teeth is thin bony wall that is more liable for resorption of the bone than other regions. The thickness of the labial bony wall is of utmost importance to determine the most suitable treatment approach ***(Braut et al. 2011)***.

Mandelaris et al., 2013 categorized the alveolar bone thickness into the crestal and radicular zones to be used in the implant planning. The crestal zone is the region from the cementoenamel junction extending to a point 4 mm apical. The radicular zone extends from the base of the crestal zone to

the root apex of each tooth **(figure 1).** Although both crestal and radicular categorized as either thick or thin. Thin is described as < 1mm of bone thickness while thick is >1 mm.

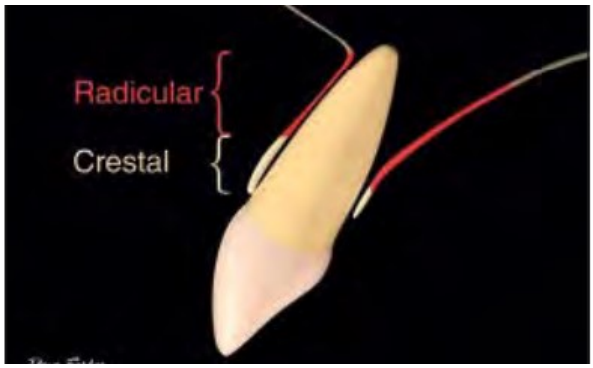

Figure 1: Schematic representation of crestal and radicular dentoalveolar zones

He also assessed each zone separately, then classified as crestal thick-radicular thick, crestal thick-radicular thin, crestal thin-radicular thick, or crestal thin-radicular thin. Results have shown that limited buccal bone loss following extraction when there is thick bone in radicular zone. While in crestal thick-radicular thin, there is increase in the risk of bone resorption. Post extraction ridge augmentation is recommended in the bone defect. Also in crestal thin-radicular thin, a large amount of post extraction buccal bone resorption is expected and need for excessive bone graft procedure.

In ***Gluckman et al., 2018*** classified radial tooth root positions and inclinations when immediate implant placement is planned **(figure 2)**:

Class I: Tooth centrally positioned within ridge

Class IA: thick facial bone wall (>1 mm)

Class IB: thin facial bone wall (<1 mm)

Class II: when Tooth retroclined

Class IIA: thick crestal bone

Class IIB: thin crestal bone.

Class III: Tooth proclined: typically, thick palatal bone, thin facial crest, thick facial wall apically

Class IV: Tooth facially positioned outside of bone envelope.

Class V: Thin facial and palatal bone walls.

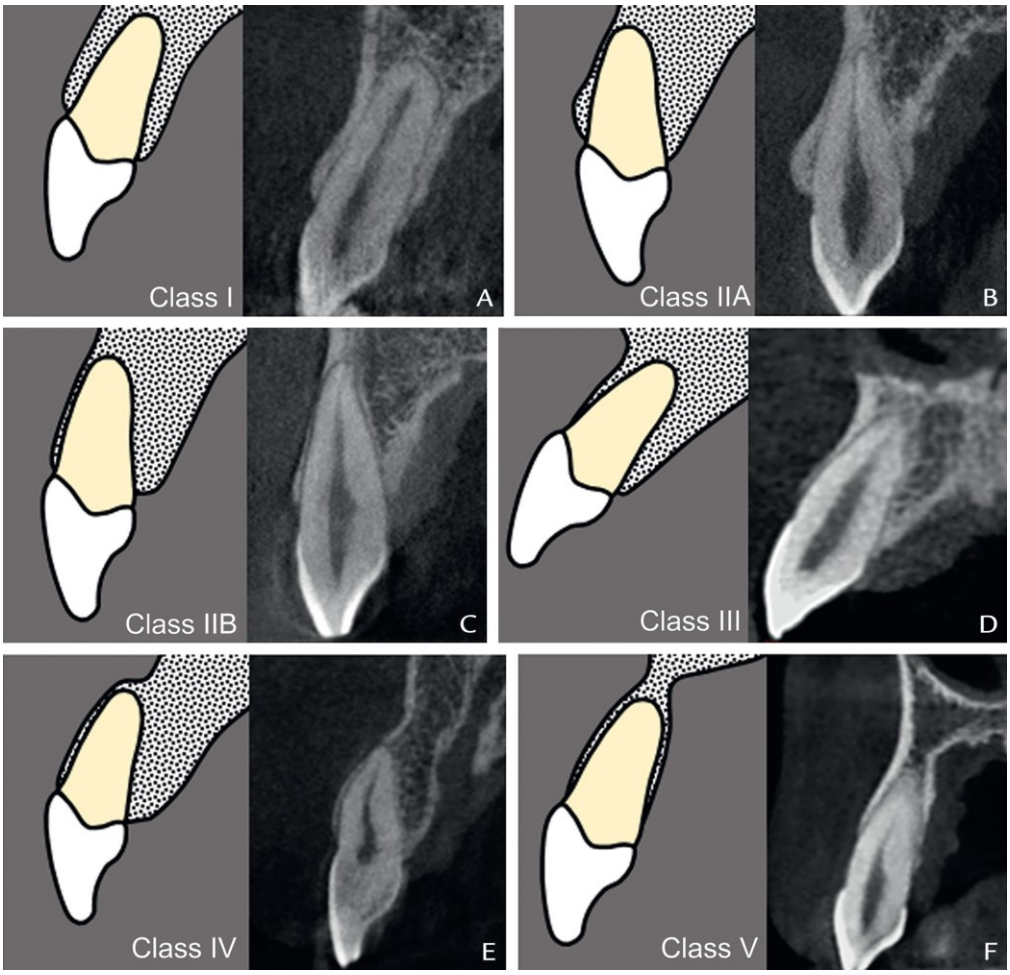

Figure 2. Radial plane tooth root positions for maxillary anterior teeth. A, Tooth centrally positioned within ridge. B, Tooth retroclined and thick crestal bone. C, Tooth retroclined and thin crestal bone. D, Tooth proclined. E, Tooth facially outside bone envelope. F, Thin facial and palatal walls (***Gluckman et al., 2018).***

Huynh-Ba et al., 2010 evaluated the dimension of the alveolar bone at extraction sites at the anterior and premolar maxillary regions. They reported that the mean width of the buccal alveolar bone was 0.8 mm from canines to canines, while the mean for premolars sites was 1.1 mm.

Januário et al., 2011 assessed the thickness of the facial alveolar bone in the anterior dentition of the maxilla. They found that, alveolar bone wall thickness was < 1 mm in most of the examined locations and was < 0.5 mm in half of assessed sites.

Wang et al., 2014 investigated the thickness of the alveolar bone and the sagittal angulation between the long axis of the teeth and the long axis of the associated alveolar bone in the anterior and premolars maxillary teeth. He concluded that almost 80% of anterior teeth and 40% of premolars exhibited a thin facial alveolar bone (<1 mm) and nearly 30% of sites had a bone wall thickness thinner than 0.5 mm.

Another study was conducted by ***Demircan and Demircan 2015*** on 60 patients to evaluate the thickness of the alveolar bone wall at maxillary incisors. Their results revealed that the bone thickness in the anterior maxillary area is very thin. Accordingly, they recommended adjunctive augmentation procedure for immediate implant treatment to be considered in such cases.

El Nahass and Naiem 2015 investigated the dimension of the facial buccal plate of alveolar bone in the anterior esthetic zone. Their results revealed that only 1% of the incisors showed a thick labial bone (1–2 mm) and 73% showed a thin bony wall (0.5–1 mm) and 25% showed very thin wall <0.5 mm at the crest of alveolar bone. While at 1 mm from alveolar crest, 7%showed very thin bony wall and 86% showed a thin bony wall while only 6% exhibited a thick bony wall. They showed at 2 mm apical to alveolar crest that only 1% of very thin bony wall, and about 85% showed a thin bony wall and 14% exhibited a thick bony level. They also demonstrated very thin bony wall and about 75% thin bony wall and 23% showed thick bony wall at 4 mm apical to alveolar crest.

Gluckman et al., 2018 evaluated the labial and palatal alveolar bone height and thickness at the anterior maxilla. They reported that labial alveolar bone thickness of the maxillary anterior teeth was predominantly thin at the crest by 83 %and the mid of the root by 92%.

Regarding the imaging modalities used to examine the thickness of buccal alveolar bone, ***Deguchi et al., 2006*** and ***Lim et al., 2007*** used CT to assess the thickness of the buccal and lingual cortical bone on the posterior region for the implantation of mini-screws. Others used micro CT for measuring the bone structures of the anterior region ***(Kim et al., 2011)***. Recently, Cone beam computed tomography (CBCT) is preferred as it provides 3-dimensional (3D) images with a great accuracy for linear measurements and improve image quality. Moreover, CBCT offers a lower radiation exposure for the patients when compared to the conventional CT ***(Huynh et al., 2010 and Patel et al., 2014).*** The CBCT considered as an appropriate diagnostic tool for 3D preoperative

planning ***(Fokas et al., 2018)***. Therefore, it will be used to accurately measure the alveolar bone thickness.

6c. Statement of the Problem

Alveolar bone thickness in aesthetic regions of the maxilla are critical factors in the selection of treatment approaches, especially when planning for immediate implant placement. Due to biologic events, alveolar bone resorption and remodeling tend to occur after tooth extraction, especially in the area of the facial bone. Hence, it is an important factor to consider, which aid in selection of implant protocol to be followed by the clinician. It also affects the success of implant placement, which in sequence affects aesthetic outcomes.

Specific Objectives:

To assess the average thickness of the alveolar bone buccal to the maxillary anterior and premolar teeth at different location using CBCT in sample of Egyptian population.

Hypothesis: null

III -Methods

A) Study design and setting

7- Study Design: An observational Cross-sectional Study

8- Setting and Location:

The CBCT data of this study will be obtained from the CBCT data base available at a private radiographic center "Dokki Radiology Center" located in Cairo, Egypt. Being a retrospective study, CBCT images of Egyptian patients who have already been subjected to CBCT examination as part of their dental diagnosis and/or treatment planning during the years 2018-till present will be included according to the proposed eligibility criteria.

B) Participants:

Based on sample size calculation, a sample of 138 CBCT images of maxillary anterior and premolar teeth belonging to Egyptian individuals will be examined. The selection of the scans to be included will be based on the following eligibility criteria.

9- Eligibility criteria and selection method:

- ✓ **Inclusion criteria:**

- CBCT scans of adult Egyptian patients, males and females with ages starting from 18.
- CBCT scans with all maxillary anterior teeth and premolars were present in the assessed quadrant.
- CBCT images of good quality without artifacts that could interfere with the assessment of the alveolar bone thickness.

- ✓ **Exclusion criteria:**

- Patients with improper tooth alignment.
- Patients with bone loss more than 3 mm from cement-enamel junction (CEJ), as the normal bone level is at 1.5-2 mm from CEJ.
- Patients with any pathological conditions or lesions affecting the normal bony architecture.
- Patients with history of chemotherapy or radiotherapy.
- Patients with dental implant, or endodontic, or prosthetic restoration, or current orthodontic treatment in the maxillary anterior and premolar region.
- Patients with labial and palatal cleft.

.

10- Matching criteria and allocation ratio:

- Not applicable in the study

C) Variables:

11- Details about variable

1. The thickness of the alveolar bone buccal to the maxillary anterior and premolar teeth at 1 mm, 3 mm and 5 mm apical to alveolar crest.
2. Mean difference of the alveolar bone thickness between genders
3. Mean difference of the alveolar bone thickness between different age groups.

12- Data Sources / Measurements:

- Retrospective Data Analysis will be performed after the CBCT images are pooled from the computer database of "Dokki radiology center"
- Scans scanned using PaX-i3D Green VATECH with 0.2 voxel resolution will be examined.
- Exposure parameters of the scans was varied depending on the individual patient's sizes.
- CBCT images will be analysed using OnDemand3D ® DENTAL (Cybermed, Seoul, Korea) using the 3D module. In the axial plane, the reference line will be oriented to pass through the center of the examined tooth perpendicular to the long axis of the tooth and buccal alveolar bone. The long axis of the tooth will dictate the orientation of the vertical slice. Bone thickness will be measured from the sagittal cross sectional cut where the CEJ will be identified and followed by the measurements in 3 different locations **(figure 3)**: A, 1 mm apical to alveolar crest ; B, 3 mm from the alveolar crest; and C, 5 mm away from alveolar crest.

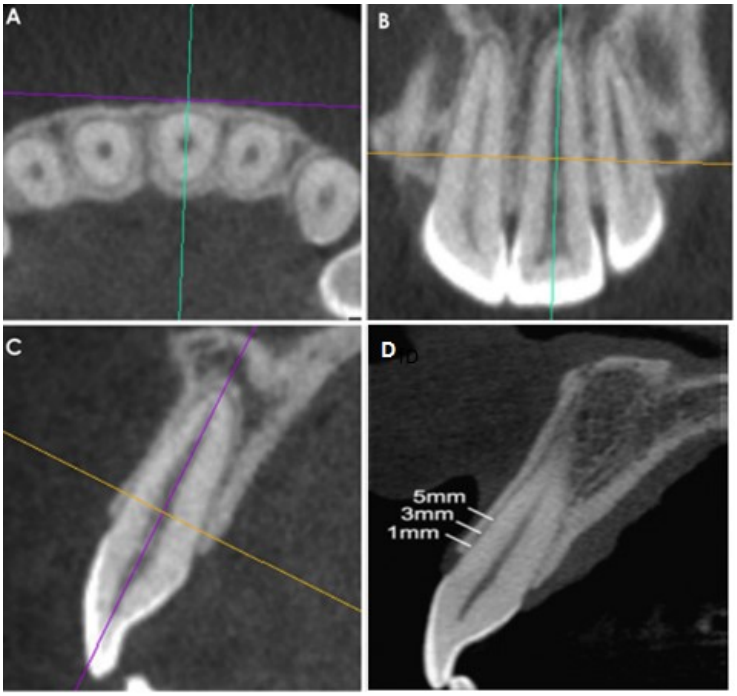

Figure 3: A. A cone-beam computed tomographic (CBCT) image in the axial plane sliced perpendicular to the labial or buccal contour of the alveolar bone of the left central incisor. B. A CBCT image in the coronal plane sliced parallel to the root axis of the left central incisor. C. A CBCT image in the sagittal plane sliced parallel to the root axis of the left central incisor. D. illustrating the positions (1, 3, and 5mm from the bone crest) of the measurements of the thickness of the facial bone wall ***(Januário et al., 2011 and Bulyalert et al., 2018).***

- CBCT images will be interpreted by two oral radiologists; blinded from demographic data of the patients and from the results of each other.
- The first radiologist will evaluate the scans for detection the thickness of the alveolar bone buccal to the maxillary anterior and premolars. Then one of them will re-evaluate the images with two weeks interval between the two reading sessions. Then the second one will evaluate a sample of the scans.
- . Intra-observer and inter- observer variability between the results will be evaluated.

13- Addressing potential sources of bias:

No source of bias. CBCT images will be interpreted by two oral and maxillofacial radiologists independently blinded from demographic data of the patients and results of each other.

D) Study Size:

14- Study Size:

The aim of this study is to assess the thickness of the alveolar bone buccal to maxillary anterior and premolar teeth among a sample of Egyptian population. Based upon the results of ***Gluckman et al., 2017***, the mean ±SD facial alveolar bone thickness of the central incisors were 0.6 ±0.3mm. Acceptable margin of error = 5%, the minimum estimated sample size was 138 patients. Sample size calculation was performed using Benchmark six sigma.

E) Quantitative variables

15- Handling of quantitative variables in analyses:

CBCT scans with maxillary anterior and premolar teeth will be examined to assess the average thickness of the alveolar bone in the Egyptian population.

The thickness of the alveolar bone of the maxillary anterior and premolar teeth will be handled as mean and standard deviation.

F) Statistical methods:

16- Statistical methods:

Data will be analysed using IBM SPSS advanced statistics (Statistical Package for Social Sciences), version 21 (SPSS Inc., Chicago, IL). Numerical data will be described as mean and standard deviation or median and range. Categorical data will be described as numbers and percentages. Comparisons between male and females for normally distributed numeric variables will be done using the Student's t-test while for non-normally distributed numeric variables will be done by Mann-Whitney test. Comparisons between categorical variables will be performed using the chi square test. A p-value less than or equal to 0.05 will be considered statistically significant. All tests will be two tailed.

IV. Ethics and dissemination

17a. Research ethics approval: The Study protocol will be submitted to the Ethics committee in Faculty of Dentistry- Cairo University for approval .

17b. Protocol amendments: Any amendments in the protocol will be reported to the main and co-supervisor.

17c. Access to Data: Investigator, Co-supervisor and main supervisor will have access to the final trial data set .

17d.Dissemination Policy: The Investigator will communicate her results with other participants and healthcare providers through publication of the protocol and the research final results and recommendations. This will be done through publication websites and journals concerned Oral and Maxillofacial Radiology specialty, For Sharing the recommended clinical application obtained from the final results of the research.

V) References:

1. Bhola, M., Neely, A.L. and Kolhatkar, S., 2008. Immediate implant placement: clinical decisions, advantages, and disadvantages. *Journal of Prosthodontics: Implant, Esthetic and Reconstructive Dentistry*, *17*(7), pp.576-581.
2. Blanes, R.J., Bernard, J.P., Blanes, Z.M. and Belser, U.C., 2007. A 10-year prospective study of ITI dental implants placed in the posterior region. II: Influence of the crown-to-implant ratio and different prosthetic treatment modalities on crestal bone loss. *Clinical oral implants research*, *18*(6), pp.707-714.
3. Braut, V., Bornstein, M.M., Belser, U. and Buser, D., 2011. Thickness of the anterior maxillary facial bone wall—a retrospective radiographic study using cone beam computed tomography. *International Journal of Periodontics and Restorative Dentistry*, *31*(2), p.125.
4. Bulyalert, A. and Pimkhaokham, A., 2018. A novel classification of anterior alveolar arch forms and alveolar bone thickness: A cone-beam computed tomography study. *Imaging science in dentistry*, *48*(3), pp.191-199.
5. Deguchi, T., Nasu, M., Murakami, K., Yabuuchi, T., Kamioka, H. and Takano-Yamamoto, T., 2006. Quantitative evaluation of cortical bone thickness with computed tomographic scanning for orthodontic implants. *American Journal of Orthodontics and Dentofacial Orthopedics*, *129*(6), pp.721-e7.
6. Demircan, S. and Demircan, E., 2015. Dental cone beam computed tomography analyses of the anterior maxillary bone thickness for immediate implant placement. *Implant dentistry*, *24*(6), pp.664-668.
7. Dos Santos, J.G., Durão, A.P.O.R., de Campos Felino, A.C. and de Faria, R.M.C.L., 2019. Analysis of the Buccal Bone Plate, Root Inclination and Alveolar Bone Dimensions in the Jawbone. A Descriptive Study Using Cone-Beam Computed Tomography. *Journal of oral & maxillofacial research*, *10*(2).
8. El Nahass, H. and N. Naiem, S., 2015. Analysis of the dimensions of the labial bone wall in the anterior maxilla: a cone-beam computed tomography study. *Clinical oral implants research*, *26*(4), pp.e57-e61.
9. Fokas, G., Vaughn, V.M., Scarfe, W.C. and Bornstein, M.M., 2018. Accuracy of linear measurements on CBCT images related to presurgical implant treatment planning: A systematic review. *Clinical oral implants research*, *29*, pp.393-415.

10. Fuentes, R., Flores, T., Navarro, P., Salamanca, C., Beltrán, V. and Borie, E., 2015. Assessment of buccal bone thickness of aesthetic maxillary region: a cone-beam computed tomography study. *Journal of periodontal & implant science*, *45*(5), pp.162-168.
11. Gluckman, H., Pontes, C.C. and Du Toit, J., 2018. Radial plane tooth position and bone wall dimensions in the anterior maxilla: A CBCT classification for immediate implant placement. *The Journal of Prosthetic Dentistry*, *120*(1), pp.50-56.
12. Grunder, U., Gracis, S. and Capelli, M., 2005. Influence of the 3-D bone-to-implant relationship on esthetics. *Int J Periodontics Restorative Dent*, *25*(2), pp.113-9.
13. Huynh-Ba, G., Pjetursson, B.E., Sanz, M., Cecchinato, D., Ferrus, J., Lindhe, J. and Lang, N.P., 2010. Analysis of the socket bone wall dimensions in the upper maxilla in relation to immediate implant placement. *Clinical oral implants research*, *21*(1), pp.37-42.
14. Januário, A.L., Duarte, W.R., Barriviera, M., Mesti, J.C., Araújo, M.G. and Lindhe, J., 2011. Dimension of the facial bone wall in the anterior maxilla: a cone-beam computed tomography study. *Clinical oral implants research*, *22*(10), pp.1168-1171.
15. Kim, H.J., Yu, S.K., Lee, M.H., Lee, H.J., Kim, H.J. and Chung, C.H., 2012. Cortical and cancellous bone thickness on the anterior region of alveolar bone in Korean: a study of dentate human cadavers. *The journal of advanced prosthodontics*, *4*(3), pp.146-152.
16. Kim, J.H., Lee, J.G., Han, D.H. and Kim, H.J., 2011. Morphometric analysis of the anterior region of the maxillary bone for immediate implant placement using micro-CT. *Clinical Anatomy*, *24*(4), pp.462-468.
17. Lim, W.H., Lee, S.K., Wikesjö, U.M. and Chun, Y.S., 2007. A descriptive tissue evaluation at maxillary interradicular sites: Implications for orthodontic mini-implant placement. *Clinical Anatomy: The Official Journal of the American Association of Clinical Anatomists and the British Association of Clinical Anatomists*, *20*(7), pp.760-765.
18. Lindhe, J., 2014. Ridge alterations following grafting of fresh extraction sockets in man. A randomized clinical trial.
19. Mandelaris, G.A., Vence, B.S., Rosenfeld, A.L. and Forbes, D.P., 2013. A classification system for crestal and radicular dentoalveolar bone phenotypes. *International Journal of Periodontics & Restorative Dentistry*, *33*(3).
20. Miyamoto, Y. and Obama, T., 2011. Dental cone beam computed tomography analyses of postoperative labial bone thickness in maxillary anterior implants: comparing immediate

and delayed implant placement. *International Journal of Periodontics and Restorative Dentistry*, *31*(3), p.215.

21. Patel, S., Durack, C., Abella, F., Roig, M., Shemesh, H., Lambrechts, P. and Lemberg, K., 2014. European Society of Endodontology position statement: the use of CBCT in endodontics. *International Endodontic Journal*, *47*(6), pp.502-504.
22. Rodriguez, A.M. and Rosenstiel, S.F., 2012. Esthetic considerations related to bone and soft tissue maintenance and development around dental implants: report of the Committee on Research in Fixed Prosthodontics of the American Academy of Fixed Prosthodontics. *The Journal of prosthetic dentistry*, *108*(4), pp.259-267.
23. Sheerah, H., Othman, B., Jaafar, A. and Alsharif, A., 2019. Alveolar bone plate measurements of maxillary anterior teeth: A retrospective Cone Beam Computed Tomography study, AlMadianh, Saudi Arabia. *The Saudi dental journal*, *31*(4), pp.437-444.
24. Singh, A., Gupta, A., Yadav, A., Chaturvedi, T.P., Bhatnagar, A. and Singh, B.P., 2012. Immediate placement of implant in fresh extraction socket with early loading. *Contemporary clinical dentistry*, *3*(Suppl 2), p.S219.
25. Singh, M., Kumar, L., Anwar, M. and Chand, P., 2015. Immediate dental implant placement with immediate loading following extraction of natural teeth. National journal of maxillofacial surgery, 6(2), p.252.
26. Ten Heggeler, J.M.A.G., Slot, D.E. and Van der Weijden, G.A., 2011. Effect of socket preservation therapies following tooth extraction in non-molar regions in humans: a systematic review. *Clinical oral implants research*, *22*(8), pp.779-788.
27. Wang, H.M., Shen, J.W., Yu, M.F., Chen, X.Y., Jiang, Q.H. and He, F.M., 2014. Analysis of facial bone wall dimensions and sagittal root position in the maxillary esthetic zone: a retrospective study using cone beam computed tomography. International Journal of Oral & Maxillofacial Implants, 29(5).