3D MAPPING OF SAFE AND DANGER ZONES OF BOTH MAXILLA AND MANDIBLE FOR THE PLACEMENT OF ORTHODONTIC MINI-IMPLANT IN MALAY CLASS II MALOCCLUSION PATIENTS

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by

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LIST OF ABBREVIATIONS

11	Upper Right Central Incisor
12	Upper Right Lateral Incisor
13	Upper Right Canine
14	Upper Right 1st premolar
15	Upper Right 2nd Premolar
16	Upper Right 1st Molar
17	Upper Right 2nd Molar
21	Upper Left Central Incisor
22	Upper Left Lateral Incisor
23	Upper Left Canine
24	Upper Left 1st premolar
25	Upper Left 2nd Premolar
26	Upper Left 1st Molar
27	Upper Left 2nd Molar
31	Lower Left Central Incisor
32	Lower Left Lateral Incisor
33	Lower Left Canine
34	Lower Left 1st premolar
35	Lower Left 2nd Premolar
36	Lower Left 1st Molar
37	Lower Left 2nd Molar
41	Lower Right Central Incisor
42	Lower Right Lateral Incisor

43	Lower Right Canine
44	Lower Right 1st premolar
45	Lower Right 2nd Premolar
46	Lower Right 1st Molar
47	Lower Right 2nd Molar
CI	Central Incisor
LI	Lateral Incisor
C	Canine
PM1	First Premolar
PM2	Second Premolar
M1	First Molar
ICW	Inter Canine Width
IPM1W	Inter First Premolar Width
IPM2W	Inter Second Premolar Width
IMW	Inter Molar Width
AL	Arch Length
AP	Arch Perimeter
Mx	Maxilla
Mn	Mandible
Rt	Right
Lt	Left
CBCT	Cone Beam Computed Tomography
CT	Computed Tomography
CBVI	Cone Beam Volumetric Imaging
TAD	Temporary Anchorage Device

3D	Three Dimensional
2D	Two Dimensional
II	Image Intensifier
CCD	Charged Couple Device
CMOS	Complementary Metal Oxide Semiconductor
TFT	Thin Film Transistor
SPSS	Statistical Package for Social Science
OPG	Orthopantomogram
ME	Method Error
MD	Mesiodistal Width
BP	Buccopalatal Width
BL	Buccolingual Width
MSIA	Maxillary Sinus Involvement Area

PEMETAAN 3D TERHADAP ZON SELAMAT DAN BAHAYA PAD KEDUA-DUA MAKSILA DAN MANDIBEL UNTUK PEMASAGAN IMPLAN MINI ORTODONTIK DALAM PESAKIT MELAYU OKLUSI TAK NORMAL KELAS II

ABSTRAK

Implan mini, kini teknik rawatan yang biasa dalam ortodontik yang menawarkan fleksibiliti, kurang invasif dan kos yang berpatutan. Implan mini telah menggantikan ankor konvensional dalam keadaan dimana ankor dianggap bahaya, tidak memuaskan dan di jangka mendatangkan efek sampingan yang tidak di ingini. Objektif utama kajian ini untuk mencari lokasi selamat diantara akar-akar gigi bagi menawarkan peta anatomi untuk menyumbangkan pakar ortodontik dengan informasi untuk pemasangan implant mini. Satu kajian retrospektif keratan rentas telah dijalankan menggunakan imej tomografi berkomputer sinaran kon (CBCT) 96 pesakit Melayu beroklusi kelas II (umur berjarak 14-30 tahun), menerima rawatan diklinik ortodontik, Hospital Universiti Sains Malaysia. Imej tersebut telah di analisa dengan perisian Plameca Romexis 3.0 (Plameca Oy, Helsinki, Finland). Sebanyak 244 pembolehubah telah di ukur setiap imej, setiap imej ruang diantara akar, jarak mesiodistal dan bukolingual di kira pada empat tahap iaitu 2mm, 5mm, 8mm dan 11mm daripada krestal tulang alveolar dan saiz gigi mesiodistal di persembahkan. T-test bebas dan t-test berpasangan telah dijalankan untuk menganalisa jarak mesiodistal, bukopalatal, bukolingual, lebar saiz gigi mesiodistal dan saiz arkus berkaitan perbezaan gender dan belah. Kajian ini menunjukan pada maksila, zon selamat untuk pemasangan implant mini ialah dari distal incisor tepi ke mesial molar kedua kearah hujung akar dibelah kanan dan mesial molar pertama untuk belah kiri. Di mandibel, zon selamat terutamanya dikawasan posterior diantara premolar pertama dan premolar

kedua. Lebar mesiodistal pada maksila menunjukan perbezaan yang signifikan antara lelaki dan perempuan pada kawasan premolar dan molar sebaliknya pada mandibel ialah pada kanin dan premolar dikedua-dua belah rahang. Lebar bukolingual tunjukan perbezaan yang ketara signifikannya antara belah kanan dan kiri pada mandibel. Penemuan-penemuan lain mendedahkan,lelaki mempunyai secara signifikannya lebih tinggi lebar bukopalatal/bukolingual, saiz mesiodistal gigi, inter kanin, inter molar dan panjang arkus dikedua belah maksila dan mandibel daripada perempuan.

3D MAPPING OF SAFE AND DANGER ZONES OF BOTH MAXILLA AND MANDIBLE FOR THE PLACEMENT OF ORTHODONTIC MINI-IMPLANT IN MALAY CLASS II MALOCCLUSION PATIENTS

ABSTRACT

The mini-implants, are now a common technique of treatment in Orthodontics which offer flexibility, minimal invasiveness and acceptable costing. Mini-implants have replaced conventional anchorage in circumstances where anchorage is considered perilous, unsatisfactory and expected to have unwanted side effects. The main objective of this research was to find safe location between dental roots to offer an anatomic map to contribute the orthodontist with the information for mini-implant placement. A cross-sectional retrospective study was performed using cone-beam computed tomography (CBCT) images of 96 Malay class II orthodontic patients (age range 14-30 years), receiving treatment in Orthodontic Clinic, Hospital Universiti Sains Malaysia. The images were analyzed by the Planmeca Romexis® 3.0 software (Planmeca Oy, Helsinki, Finland). A total of 244 variables were measured in each image, in every image interradicular space, the mesiodistal and the buccolingual distances measured at four cut levels of 2mm, 5mm, 8mm and 11mm from the alveolar crest and mesiodistal tooth size width along with arch size. In this study, measurements from the right sided second molar to the left sided second molar in both maxilla and mandible are presented. Independent t-test and paired t-test were conducted to analyze the mesiodistal, buccopalatal, buccolingual distances, mesiodistal tooth size width and arch size consequently gender and side disparities. The study shows that in maxilla, the safe zone for mini-implant placement are from distal of lateral incisor to mesial of second molar towards the apices for the right side and mesial of first molar for the left side. In the mandible, safe zones are mainly in posterior region between first premolar

and second molar. Mesiodistal width of maxilla shows significant differences between male and female at premolar and molar region whereas in mandible was at canine and premolar region in both side of the jaws. Buccolingual width shows obvious significant differences between right and left side in mandible. Other findings revealed, male has significantly higher buccopalatal/buccolingual width, mesiodistal tooth size width, intercanine, interpremolar, intermolar width and arch length in both side of maxilla and mandible than female.

CHAPTER 1

INTRODUCTION

1.1 Background of study

By definition “Orthodontics is the study of growth and development of jaws and face particularly and the body generally, as influencing the position of the teeth, and the study of action and reaction of internal and external influences on the development, prevention and correction of arrested and perverted development.” (British Society of Orthodontics, 1922). According to Angle’s (1907) definition “Orthodontics is the science of correction of malocclusion of teeth.” In 1899 angle gives his first classification of malocclusion, Class I, Class II and class III, among them class II malocclusion or distocclusion is where the mesiobuccal cusp of the upper first molar is aligned anterior to the mesiobuccal groove of the lower first molar. In class I or normal occlusion the mesiobuccal cusp rests in between the first mandibular molars and second premolars. There are two subtypes:

Class II Division 1: The molar relationships are like that of Class II and the anterior teeth are protruded.

Class II Division 2: The molar relationships are Class II but the central are retroclined and the lateral teeth are seen overlapping the centrals.

As Proffit says “anchorage is resistance in tooth movement”. In treatment of class II malocclusion, anchorage is needed which must not move at all. The molars and canines or some intra oral or extra oral orthodontic appliances were used as conventional anchorage. But they have limitations like increased amount of orthodontic force lead to movement of molars used as anchorage, and these may eventuate even in case of appliances also. Well managed conventional anchorage can give good results (Youssef, 2015).

Mini-implants, also called mini-screws or temporary anchorage devices (TAD), are very small screw-like devices. As it gives good stability it gives good anchorage. Usually mini-implants are fixed to bone and then allied with tooth to move them during treatment (Youssef, 2015).

Mini-implants can be inserted into maxilla or mandible. Positioning areas can be the palate, interdental area, premaxilla or pogonion. An intraoral radiograph is required to determine the correct location for mini-implants placement. Better using modern three-dimensional (3D) radiograph over conventional two-dimensional (2D) radiograph to locate safe and danger zone of mini-implant insertion (Youssef, 2015).

Cone-beam computed tomography (CBCT) is a special type of x-ray equipment, when two-dimentional (2D) x-rays are not adequate. Dentist may use this to get three dimensional (3D) images of teeth, soft tissues, nerve, vessels and bone by only single scan. CBCT imaging is being frequently applied for orthodontic assessment (Farman, et al., 2009). Regarding exposure to radiation, the lowest doses to patients may deliver by conventional images. CBCT is preferred over a CT image when 3D imaging is required in orthodontic practice. (Lin, 2010). In orthodontic diagnosis and treatment planning accurate diagnostic imaging is a key factor for proper evaluation. In addition, it is important that allows orthodontist to closely monitor treatment progress and outcome (Ghoneima et al., 2009). CBCT is considered to overcome some limitations of conventional computed tomography (CT) scanning device and radiograph.

Advantages of CBCT over standard 2D x-ray radiographs:

- 3D representation of oral and maxillofacial region;
- Negligible magnification errors or projection stuffs;
- Generation of data that can be used in other diagnostic, modelling, and manufacturing application.
- The exposure of radiation within a similar range of other dental radiographic imaging devices, which is usually an order of magnitude lower than medical CT devices (Rustemeyer et al., 2004; Schulze et al., 2004; Mah et al., 2003; Ludlow et al., 2003).

1.2 Statement of the problem

An implant is a surgical element, interfaces with the jaw bone or mid face to act as an orthodontic anchor or to support a dental prosthesis such as a crown, bridge, denture, facial prosthesis. The base for modern implants is a biologic process called osseointegration where materials, such as titanium, form an intimate bond with bone. Osseointegrated implants are considered reliable sources of anchorage for orthodontists (Roberts et al., 1990, Wehrnein and Merz, 1998, Gray et al., 1983, Roberts et al., 1984, 1989 and Odman et al., 1988). Mini-implants were developed to offset the limitation of large implants because of their size (Carano and Melsen, 2005, Ohmae et al., 2001, Cope, 2005, Kanomi, 1997, Berens et al., 2005, Miyawaki et al., 2003). Not only size but their minimal anatomic limitations, minor surgery, increased patient comfort, immediate loading, and acceptable lower costs are the primary advantages (Berens et al., 2005, Miyawaki et al., 2003, Costa et al., 1998, Freudenthaler et al., 2001 and Fritz et al., 2004). Other terms such as mini-screws, miniscrew implants, micro-screws, and temporary anchorage devices (TAD) have been used as they are used for specific time periods, mostly rely on mechanical retention, and not always osseointegrate (Heymann and Tulloch, 2006, Papadopoulos and Tarawneh, 2007).

The most common implant placement sites seem to be the palate, the posterior aspect of the maxillary alveolar process, the retromolar area in the mandible, and the buccal cortical plate in both the maxilla and the mandible (Park et al., 2006, Roth et al., 2004, Park et al., 2007, Kanomi, 1997, Xung et al., 2007). Interradicular distances and adjacent soft-tissue anatomy are the significant factors that must be considered when selecting the sites for mini-implant placement. Interradicular measurements are measured from the basis of alveolar crest and thus measurements vary with alveolar bone levels due to resorption. The interradicular distance gradually increase apically and measures highest at the apical level. The interradicular spaces at the posterior region of maxilla and mandible are measured to facilitate mini-implants insertion in that region as anchorage for extrusive or intrusive movement of the anterior teeth or to correct the vertical occlusion. The interradicular spaces at the anterior maxilla and mandible can also be used for mini-implant insertion for mesial movement of the posterior teeth or correction of the anterior vertical occlusion. (Park et al., 2007, Kanomi, 1997, Xung et al., 2007).

In orthodontics, dimensions of arches are significant for the teeth position, aesthetics, and teeth stability. To achieve treatment goals the shape and form of arch are usually altered. It is modified using different wires, to affect the arch form and dimensions (Anwar and Fida., 2010).

Tooth size and arch size have an important aspect in orthodontic treatment procedure. The conventional way to measure tooth size and arch size is from dental model using hand-held callipers and scale (Zilberman et al., 2003). Recent technological developments have presented the advanced digital callipers, had been used for measurements of tooth size. Now three-dimensional (3D) technology has made a revolution in orthodontic diagnosis and treatment method, using 3D technology dental model casting is done digitally, following measurements. (Bell et al., 2003; Zilberman et al., 2003). Measurement and analysis in digitally casted model is much more easy and accurate (Leifert et al., 2009). Now, there is available reliable software for conducting measurement analysis, model storage thus reducing the cost. (Leifert et al., 2009; Stevens et al., 2006).

1.3 Justification of the study

Since correction of angle class II malocclusion with mini implants has been debated for many years. Our study will be focusing on determining the specific safe and danger zone in maxilla and mandible for insertion of orthodontic mini implants for a higher anchorage and success rate. No such study has been done in Malay population. The benefits of this study are-

- The specific safe and danger zone in maxilla and mandible for insertion of orthodontic mini implants can be determined.
- Gender disparities of different safe and danger zone of orthodontic mini implants can be established.
- Side disparities of different safe and danger zone of orthodontic mini implants can be revealed.
- Determination of appropriate (diameter and length) of mini implants.

CHAPTER 2

LITERATURE REVIEW

2.1 Cone-beam computed tomography (CBCT):

Dental radiology was completely depended on 2-D images, like intraoral radiographs and panoramic radiographs. But after the advent of cone beam computed tomography (CBCT), using 3-D imaging technology has facilitated accurate diagnosis and treatment planning. CBCT is improved variation of conventional computed tomography (CT) and is used particularly in dental and extremity imaging. It differs from conventional CT in that it uses cone-shaped x-ray beam and 2-D detectors instead of fan-shaped x-ray beam and one-dimensional detectors. The source detector system performs one rotation around the object producing a series of two dimensional images (De Vos et al., 2009). The images are recreated in a three-dimensional data set using a modification of the original cone-beam algorithm developed by Feldkamp and co-workers (Feldkamp et al., 1994). Mozzo et al., (1998) from Italy and Arai et al., (1999) in Japan gave early statement of the use of CBCT.

CBCT or Cone-beam volumetric imaging (CBVI) have distinguish technique from the conventional computerized tomography (CT). In CT machine about 60 rotation of x-ray source per minute happen in the area selected like the maxilla or mandible. Multiple sensors sense the x-ray beam. The patient slides into the hallow tube at the slice thickness (1mm to 1cm) determination rate. The information from the sensors (made of gas or scintillator material) will be restored as the three-dimensional image in a computer. This detailed image acquisition requires capacious data for which patients exposed to high radiation (Miles.D.A, 2008). A regular CT scan have radiation dose of almost 2100µSv for maxilla, comparable to the dose required for 375 panoramic radiograph (Miles.D.A, 2008).

CBCT technique is a 360° scan where x-ray source rotates around the patient's head with area detector. CBCT units can be categorized according to their radiation detecting system such as an image intensifier tube (IIT), complementary metal oxide semiconductor (CMOS), thin film transistor (TFT) flat-panel imager (FPI) (Floyd et al., 1999). With less distortion, good scale of contrast and elimination of glare in these new detectors. CBCT radiation doses are approximately 40 to 500 µSv (Ludlow et al., 2003).

The quality of the image depends on several factors, the most important are the resolution and contrast (Tsiklakis et al., 2005). As it sunders 3-D image, its implication in orthodontics is highly beneficial. assessment of TMJ, airways, facial growth and estimation of age can be done.

The limitation of CBCT are the relative small detector size, the field of view and scanned volume are limited. There is also a low contrast resolution which limits the visualization of internal soft tissue (De Vos et al., 2009).

2.2 Orthodontic mini implant:

Implants are an excellent alternate to conventional anchorage techniques. Gainsforth and Higley in 1945 for the first time revealed about orthodontic implants for improvement of anchorage. Vitallium screws were used by them, which were implanted in the ramal area. The implants were instantly loaded to retract canine in the upper arch. Regrettably, all implants were lost within a month (Gainsforth and Higley, 1945).

Linkow, (1970) used an implant for substituting a missing molar, in the purpose of retracting upper anteriors. His results were relatively inspiring (Linkow et al., 1970). Near the end of 1980s clinicians gave attention on the use of standard dental implants as an anchorage for orthodontic tooth movement and as permanent abutments for replacement. Creekmore, (1983) designated the vitallium implants for having anchorage for intrusion of upper anterior teeth. The screws were implanted just below the ANS, then loaded after 10 days and orthodontic force was applied using an elastic thread. Within a year 6mm of intrusion was established. (Creekmore, 1983)

New on-plants, miniplates and palatal implants have been specifically developed for usage in orthodontics. Recent development in min-implants for space closure and distalization of maxillary molars the mini plate implants have been used. Most orthodontists have turned to mini-implants, as most of showing improved results than standard dental implant realizing its efficacy as orthodontic anchorage (Jasoria et al., 2013).

Kanomi, (1997), first described mini implant of 1.2mm diameter and 6mm length to be used as orthodontic anchorage. He was successful in using this mini-implant for intrusion of the mandibular incisors. The implant was inserted between the mandibular central incisors, 2 to 3mm from the root apex (Kanomi, 1997).

The initiation of mini-implants had transformed orthodontic anchorage and simplified the biomechanics. Mini-implants can be used for all orthodontic movements successfully (Maino et al., 2003). Mini screw implants have progressively been used for orthodontic anchorage for their utter anchorage, easy placement and removal, and low cost (Kim et al., 2005).

Mini-implants had extensively used in the last few years because of its advantages over regular anchorage. (Deguchi et al., 2003, Carano et al., 2004, Creekmore and Eklunde, 1983, Bae et al., 2002) The screw type mini-implants, used for orthodontic anchorage can be inserted in between roots. The small screw diameter and length reduce invasiveness of these implants (Kanomi, 1997). Mini-implants have been used to great advantage in the field of orthodontics (Kanomi, 1997, Park et al., 2002). Poggio and his colleagues in 2006 try to find the safe and danger zones in posterior region of maxilla and mandible (Poggio et al., 2006).

Many researchers used different types of mini-implants. They can be classified depending on how they attached to bone, size and shape and according to application. According to Labanauskaite et al., (2005) implants can be classified as follows:

- Depending on size and shape: Conical implant, miniplate implant and onplant.
- Depending on contact with bone: Osseointegrated and Non-osseointegrated.
- Depending on application method: Orthodontic implants and Prosthodontic implants. (Labanauskaite et al., 2005)

Implants consists of three parts: Head, neck and body. Head design is most common as button like with spheres. Head diameter is largest among other parts. In the neck region there is a hole and diameter are lower than head. There may be some design like bracket and hook. These design for direct and indirect anchorage. The body or thread is conical shape or parallel shape with tapering at the apex. The diameter ranging from 1mm to 2.5mm is available and length may differ from 6mm to 14mm (Figure **2.1**).

Despite advantages there are some complication of mini-implant during and after insertion as an anchorage in inappropriate locations.

- Inflammation, infection, and tissue irritation

Inflammation and infection of the tissues around the implant site might occur, although infection is generally not a problem. (Melsen, 2005, Melsen and Verna, 2005, Herman and Cope, 2005, Maino et al, 2005) One important factor to help avoid tissue inflammation is the determination of the best site for mini-implant insertion. (Miyawaki et al, 2003) It is advised that the mini-implant should be inserted in keratinized gingiva when possible (Melsen, 2005, Herman and Cope, 2005) and that frenum and muscle tissue should be avoided. (Park et al, 2003, Miyawaki et al, 2003)

- Hypertrophy of the mucosa covering the implant

This might occur as a complication of placing it in nonkeratinized gingiva. (Herman and Cope, 2005)

- Injury to adjacent structures

Another complication concerning mini-implant insertion is injuring adjacent roots, periodontal ligaments, nerves, and blood vessels. (Melsen and Verna, 2005, Herman and Cope, 2005, Maino et al, 2005, Park et al, 2003) In such circumstances, the mini-implant should be removed. (Melsen, 2005, Maino et al, 2005)

- Maxillary sinus perforation
- Failure

Failure of the mini-implant might occur if there is lack of stability at insertion time due to inadequate thickness of the cortical bone. (Melsen and Verna, 2005)

- Lose or loosening of mini-implant

The mini-implant may be lost or become loose because of various factors, such as inflammation of the peri-implant tissues and improper placement. (Melsen and Verna, 2005, Herman and Cope, 2005)

- Fracture

Fracture of the mini-implant may occur during insertion or removal if the neck of the screw is too narrow. (Melsen, 2005, Park et al, 2003)

The safe zone is where adequate length of implant can be inserted without damaging the vital structures like root, periodontal ligaments nerve in mandible and sinus in maxilla. These zones can be determined by measuring interradicular space, mesiodistal space. The safe zones also improvised orthodontic mechanism. In safe zone of maxillary posterior region mini-implants can be used as independent appliances for anterior teeth retraction simultaneously and intermaxillary elastics used with mini-implants to retract the lower anterior teeth.

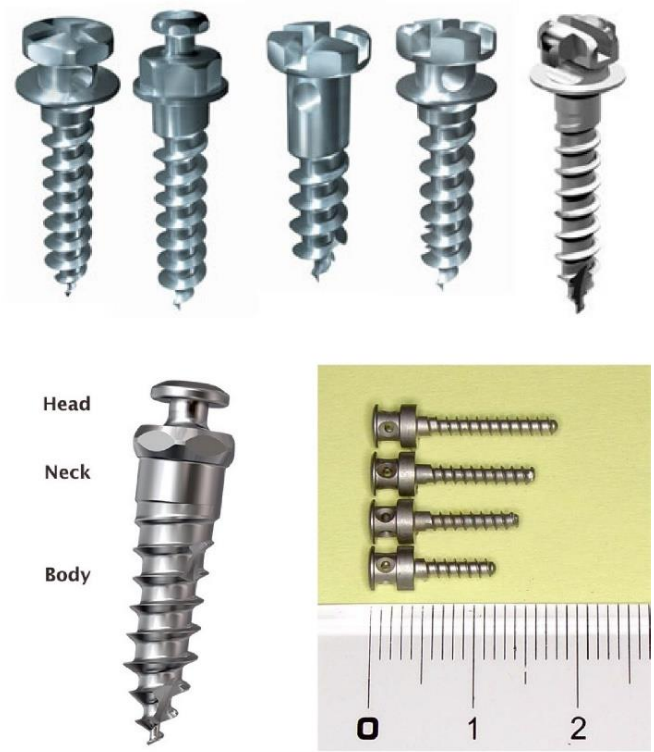

Figure 2.1: Different head design for orthodontic mini implant (Jeil Medical Corporation, Korea), Different lengths (8, 10, 12, 14 mm) of mini-implants, Different parts of mini-implant (Studio Dentaire, 2015). (Clockwise)

The danger zone is literally inappropriate for mini-implant placement where the interradicular and mesiodistal space are inadequate. Root damage and premature loss of mini-implant is common in these sites (Park and Cho, 2009). Mini-implant can fail to provide solid anchorage and may loosen or fracture. (Kim et al., 2009).

2.3 Class II malocclusion:

Edward Angle in 1899 defined class II malocclusion as the mandibular first molars occlude distal to the normal relationship with the maxillary first molar. He added two divisions, division one and division two. In division one maxillary incisors protruding, the maxillary incisors retruding in division two. However, the British Dental Institute in 1983 defined class II as, lower incisor edges lie posterior to the cingulum of the upper incisors which are proclined or of average inclination and there is an increased overjet (Proffit, 2014, Bishara, 2001).

Recently found that class II malocclusion prevalence was to be between 15% and 30% in different populations and It is one of the most common malocclusion among all. (Oztoprak et al., 2012) (Vásquez et al., 2009, Silva and Kang, 2001, Lew et al., 1993, Garner and Butt, 1985) Mandibular deficiency was proven to be the most dominant component of this malocclusion. (McNamara Jr, 1981, Perillo et al., 2012)

There are some etiological factors for class II malocclusion like skeletal, soft tissues, dental factors and habits, the prevalence of class II is high. Angle’s estimated 27% of malocclusion could be class II malocclusion, while National Health and Nutrition Examination Survey (NHANES) found 33% of class II. Skeletal discrepancies are the most common cause of class II malocclusion (Bishara, 2001). Protrusion of maxilla, retrusion of mandible and combination of both could be the reason of skeletal class II. McNamara found an interesting statistic, that 75% of class II skeletal discrepancies are due to mandibular retrognathia (Proffit, 2014).

2.4 Interradicular space:

Poggio used 25 images of cone-beam computed tomography (CBCT) to estimate mesiodistal and buccolingual width of maxilla and mandible for mini-screw insertion. Measurements were carried out at posterior region of maxilla and mandible and from level of alveolar crest. According to study in the maxilla at 5mm depth mesiodistal bone was the most in between the second premolar and first molar and in between canine and the first premolar at 11mm depth. Between first and second molars the buccopalatal dimension of the maxilla, was the most at 5mm from the alveolar crest. In the mandible, at 11 mm depth between first and second premolar the greatest amount of mesiodistal bone was present. In mandible in between the first and second molars at 8 mm depth the buccolingual dimension was the greatest (Poggio et al., 2006).

Hernandez and co-workers in 2008 provided a map for of mini implants insertion using 21 CT of maxilla in Spanish population. Their studies showed between lower first and second molar there was most mesiodistal spaces. They measured at three levels (3mm, 6mm and 9 mm) from the alveolar crest and lingual and palatal side would not be an imitating factor for the implants insertion (Hernandez et al., 2008). Kim focused on the mesiodistal width between the maxillary second premolar and first molar of 35 patients. They measured from the cementoenamel junction (CEJ) and found the interradicular spaces are wider toward the apex. The average distance at 3mm to 9 mm from the cementoenamel junction was 5 mm (Kim et al., 2009). Biavati and co-researchers from Italy measured the cortical bone thickness and the mesiodistal width in the 25 CT scan images to find the position of orthodontic mini screw placement. They concluded, in maxilla and in the mandible only 13% sites and 63% sites were suitable respectively. They consider mini-screw diameter of 1.3mm (Biavati et al., 2011). Lee and colleagues from Korea assessed the mesiodistal space in 30 students who have normal occlusion. They measured at the depth of 2, 4, 6 and 8 mm based on cementoenamel junction. They found the maxillary mesiodistal width in anterior region was more than 3mm at 8mm level, in between the two premolar and at the 4mm level in between the second premolar and first molar. In mandible, in between the two premolars, in between the two molar and in between the second premolar and the first molar at the 4mm level more than 3mm width was found (Lee et al., 2009). Park and Cho measured mesiodistal and buccopalatal width of 60 adults. Their outcomes showed the maxillary mesiodistal width extended from 1.6 to 3.46 mm and increased towards apical region. The distance between second premolar and the first molar were most and mandibular mesiodistal width were more than the maxillary width which fluctuated from 1.99 to 4.25mm. Buccopalatal widths were 3.74 to 5.78mm and 3.11 to 7.84mm in the maxilla and in the mandible correspondingly (Park and Cho, 2009).

In a study orthopantomogram (OPG) images of 60 patients Schnelle and co-workers found adequate mesiodistal bone mesial to first molar and in mesial and distal of first molar in the maxilla and in mandible respectively. The space was located at half of the root height (Schnelle et al., 2004).

Wey and co-workers also have measured the interradicular space of Mongoloids. They used digital orthopantomogram (OPG) of 32 patients and measured only at posterior region. They found the average width from the cervical margin at 2mm was 2.58; at 5mm were 3.47; at 8mm was 4mm and at 11mm was 4.36mm. They recommended the area from 5mm to 8 mm from CEJ as the safest area for mini-implant insertion (Wey et al., 2012).

2.5 Tooth size:

Tooth size is represented by the mesiodistal width of the maxillary and mandibular teeth (Othman and Harradine, 2007). Although, most of the individuals have match in their natural tooth proportion, 5% of the population show some degree of disproportion in the teeth size (Proffit et al., 2006). Many populations indicate inter maxillary tooth size discrepancy (Crosby and Alexander, 1989; Freeman et al., 1996).

2.5.1 Measurement of tooth size:

Mesio-distal dimension, buccolingual dimension and occlusogingival dimension are the common linear systems applied by maximum traditional morphometrics; whereas indices are utilized in others to represent size (Kieser et al., 1985). Some form of odontometry is practiced by numerous orthodontists as part of diagnosis (Peck and Peck, 1975). Studies investigating tooth morphology usually differentiate metrical and non-metrical variations. Metrical variations are termed as all aspects measured directly (i.e., the mesiodistal crown diameters of teeth); while scoring or illustrating the incidence, absence, and degree of development or form visually are considered to non-metrical variations. Difficulty in assessment is mainly the reason for the complexity of non-metric aspects requiring the need for a standardized test.

Model analysis is considered pivotal in orthodontic diagnosis and treatment planning despite of the fact that it is time consuming. The models are subjectively judged by the orthodontist without applying the analytical tests (Binder and Cohen, 1998). Utilization of digital calipers for measurement of tooth size made the method easier and aided in eliminating further mistakes compared to conventional method of using (Ho and Freer, 1999). In recent times, digitally 3-D reconstructed virtual model from CBCT scan are used for measurements. Its accuracy is acceptable and considering its advantage of a 3D virtual model procedure had become the day-to-day standard for orthodontic use (Zilberman et al., 2003, Baumgaertel et al., 2009). Calculation of tooth width measurements using CBCT are also acceptable. CBCT measurements can be used instead of conventional dental model measurements (Celikoglu et al., 2013, Baumgaertel et al., 2009)).

2.5.2 Mesiodistal dimension:

Distance from the anatomical contact of one tooth to the other from the buccal side of the tooth or from the occlusal side for the rotated tooth is said to be the mesiodistal width of tooth (Bishara, 2001). Traditionally, mesiodistal width assessment involved measurement techniques on the dental models either by sharp pointed dividers, sliding calipers, or Boley gauge (Shellhart et al., 1995) and recently on digital model reproducing from 3D scan (Zilberman et al., 2003, Baumgaertel et al., 2009).

Mesiodistal diameter of the crown have been named variously over time, such as tooth width (Moorreeset al., 1957), mesiodistal width (Bolton, 1958), tooth breadth (Lundstrom, 1955) and mesiodistal crown diameter (Lavelle, 1968). Mesio-distal dimension was defined by Moorrees and colleagues in 1957 as the greatest distance between the contact points using calipers by holding them parallel to both the occlusal and vestibular surfaces; in contrast to Kieser et al. (1985) who defined it as the maximum distance between the contact points of a tooth in normoocclusion (Kieser et al., 1985). In the case of rotated or displaced tooth, complications may arise (Moorrees et al., 1957). Measuring a line between the mesial and distal contact points of each crown when the teeth are in the normal occlusion is another way of defining mesiodistal dimension established by other researchers (Scott and Turner, 1988). Interestingly, most of the researchers have specified mesiodistal dimension line as the maximum distance between contact points. However, teeth with marked proximal and occlusal attrition may be excluded (Kieser, 1990). On the other hand, the largest distance between the normal contact points on the proximal regions of the tooth crown, measured parallel to the occlusal plane is considered as the mesiodistal line in few studies (Lavelle, 1971). A more accurate measurement of the mesiodistal line can be obtained parallel to the occlusal and buccal surfaces (Axelsson and Kirveskari, 1983, Potter et al., 1981).

2.6 Arch size:

Arch dimension comprises of the arch length, arch width and depth. Modification of the arch form and shape are usually performed in orthodontic treatment to achieve the treatment goals. The dimensional alterations customized by the several forms of wires used in the treatment course affect the arch form and its dimension (Anwar and Fida, 2010). The patient’s existing arch form appear to be the best guide for the stability of the arch form following treatment because of the relapse tendency to its original shape (Cruz et al., 1995).

In clinical orthodontics, determination of arch form and its dimension is vital for esthetics and long-term occlusal stability by maintaining the original mandibular inter-canine width and preservation of the original arch form (Nojima et al., 2001).

The arch size and shape are of meticulous importance to orthodontists. Hence, to help and forecast dental arch growth and assist in treatment planning, a diverse diagnostic and analytical indices had been developed (Nimkarn et al., 1995).

Dental arch expansion is alternatively used to relieve crowding and adjusting arch length to solve the problem of extraction in orthodontic treatments. After dental arch expansion avoiding the relapse is the most controversial (Smith et al., 2000).

As a result, many researchers formulated indices and techniques using tooth size to calculate the perfect interpremolar and intermolar arch width for achieving an ideal expansion of arches to avoid the relapse tendency, keeping them stable and alleviating the crowding (McNamara, 1993).

CHAPTER 3

OBJECTIVE OF THE STUDY & HYPOTHESIS

3.1 General objective

The prime aim of this study is to provide the orthodontists/surgeons with a guide for the safe placement of orthodontic mini-implant in Malay population with class II malocclusion by the 3D mapping of the safe and danger zones in the maxilla and mandible.

3.2 Specific objectives

- To compare the mesiodistal and buccopalatal/buccolingual distances of bones in between tooth roots at different levels from the alveolar crest in both the maxilla and mandible for gender and side disparities.
- To compare the mesiodistal tooth size in both maxilla and mandible for gender and side disparities.
- To compare arch size in both maxilla and mandible for gender disparities.

3.3 Research question

- Are there any safe and danger zones for insertion of mini-implants in both maxilla and mandible?
- Are there any gender and side disparities in the mesiodistal and buccolingual distances of bones in between tooth roots at different level from the alveolar crest in both the maxilla and mandible?
- Are there any gender and side disparities in the tooth size in both maxilla and mandible?
- Are there any gender disparities in the arch size in both maxilla and mandible?

3.4 Null hypothesis

- There are no safe and danger zones for insertion of mini-implants in both maxilla and mandible.
- There are no significant gender and side disparities in the mesiodistal and buccolingual distances of bones in between tooth roots at different level from the alveolar crest in both the maxilla and mandible.
- There are no gender and side disparities in the tooth size in both maxilla and mandible.
- There are no gender disparities in the arch size in both maxilla and mandible.

CHAPTER 4

MATERIALS AND METHODS

4.1 Study design

This is a Cross sectional study.

4.2 Population and sample:

4.2.1 Study population:

Malay ethnic group.

4.2.2 Study Area:

The subjects were recruited from the archive of the Radiology Department and Orthodontic clinic, School of Dental Sciences, Hospital Universiti Sains Malaysia (HUSM) and research was conducted in School of Dental Sciences, HUSM. This study was approved by the Jawatankuasa Etika Penyelidikan Manusia USM (JEPeM) (Human Research Ethics Committee) (USM/JEPeM/17040238), which conforms with The Helsinki Declaration.

4.2.3 Sampling Method and subject recruitment:

With the permission of the Hospital Director, the data has collected from the medical record file of the orthodontic clinic, School of Dental Sciences, Hospital USM to obtain the patients list undergoing orthodontic treatment for class II malocclusion. The registration number of the Malay patients (From record file we get information about IC number, citizenship, race and parents name. This information verifies at least two generation of being Malay) were sorted out and imaging records of the cone-beam computed tomography (CBCT) were requisitioned from Planmeca Promax 3D machine (TDX260835) at an energy of 90 kV, a current of 10-15 mA and voxel size 320 µm through Planmeca Romexis software. CBCT images were analyzed without affecting the record and management.

Confidentiality of the patients has preserved. All the data collected from CBCT images have anonymously exported to SPSS software. Data were presented as the sample images cannot be identified independently.

No new CBCT were done for this study.

4.3 Sample Frame

4.3.1 Inclusion criteria

- Age ranging from 14 and 30 years.
- Patients with all sound erupted permanent teeth (except 3rd molar) with no history of previous orthodontic treatment.
- ¼ or half step class II div 1 requiring extractions of first premolars bilaterally in upper arch with proclined upper incisors.
- Good quality CBCT acquisitions
- Sample recruited from Malay population (verified from files).

4.3.2 Exclusion criteria

- Severe crowding.
- Excessive spacing.
- Radiographic evidence of any pathology within the maxilla and mandible.
- Missing or supernumerary teeth.
- Abnormal size or morphology of teeth.
- Teeth wear that effect the tooth size measurement.
- Periodontal disease.