INCISIVE PAPILLA AS A BIOMETRIC REFERENCE TO MAXILLARY ANTERIOR TOOTH POSITIONS AMONG KENYANS OF AFRICAN DESCENT

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DECLARATION

I, Cyril Nyalik Ogada, hereby declare that this work is my original work and has not been submitted, in part or in full for the award of a degree, diploma or certificate of this or any other University or examination board.

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DEDICATION

This thesis is dedicated to my sister, the late Veronica Akinyi Ogada and my parents Mr Benard Ogada and Mrs Leo Akello Ogada.

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ACRONYMS

BDS Bachelor of Dental Surgery

CHS College of Health Sciences

KEBS Kenya Bureau of Standards.

mm Millimeters

Nbi Nairobi

SPSS Statistical Package for Social Sciences

UoN University of Nairobi.

DEFINITION OF TERMS

Age	The chronological age of the participants as at last birth day.
Incisive papilla	A pear-shaped prominence on the hard palate that lies at the anterior extremity of the mid-palatine raphe.
Inter-canine line	A straight line passing through the tips of the maxillary left and right canines.
Inter-canine width	The distance in millimeters between the tips of the left and right maxillary canines.
Plaque	An adherent deposit of bacteria and their products, which forms on all tooth surfaces and is one of the causative factors of dental caries.

ABSTRACT

Introduction: Denture aesthetics is key in patient satisfaction with complete denture treatment. Positions of maxillary anterior teeth are critical in the aesthetic outcome of complete dentures. Positions of denture teeth are best determined using pre-extraction records, but most persons who seek complete denture construction in Kenya do not have these records. Biometric guides have been used to determine positions of prosthetic teeth, the most common one being the incisive papilla. This study sought to describe the relationship between the incisive papilla and the maxillary anterior teeth among Kenyans of African descent.

Aim: To describe the relationship between the incisive papilla and the positions of the maxillary anterior teeth among Kenyans of African descent.

Materials and Methods: Maxillary impressions were taken of 112 participants from the College of Health Sciences (CHS) of the University of Nairobi (UoN) using irreversible hydrocolloid and generated in Type IV gypsum. The canine tips and the posterior limit of the incisive papilla were marked on each cast. Photocopies of the casts were taken at 1:1 ratio. On the photocopies a line was drawn to connect the canine tips. Lines through the posterior limit of the incisive papilla and the most labial aspect of the right central incisor were drawn parallel to the inter-canine line. A perpendicular line was drawn connecting the three lines. The distance between the lines was measured in mm using a digital caliper. Each subject was instructed to stand upright and place his/her head in the physiologic natural head position looking at the horizon. With the head in this position, the relationship between two lines was noted; one line dropped from the bridge of the nose to the base of the upper lip and a second one extending downward to the chin. Facial profile was judged as straight if the three points were on a straight line, convex if the middle point (base of upper lip) was anterior to the two other points and concave when the middle point was posterior to the other two points. The somatotype was categorized by the investigator based on the general body build of the subject as ectomorphic (tall and thin), mesomorphic (average) and endomorphic (short and fat).

Results: This study was conducted among students of CHS, UON aged 18-35 years. The most labial aspect of maxillary central incisor was a mean of 14.93±1.52mm from the posterior limit of the incisive papilla. This was statistically different from findings from Caucasian populations ($p<0.001$). This distance did not vary with the gender ($t=0.52$, $p=0.61$), facial profile ($t=0.93$, $p=0.35$), or body type ($F=1.05$, $p=0.35$). There was a weak correlation between this distance and the age ($r= -0.178$, $p=0.061$). The inter-canine line was a mean of 4.73±1.73mm anterior to the most posterior limit of the incisive papilla. This finding contradicts recommendations from Caucasian studies ($t=28.93$, $df= 111$, $p<0.001$). There was weak correlation between age and the distance from the posterior margin of the incisive papilla to the inter-canine line ($r= -0.13$, $p= 0.15$). There was no variation on the relationship between the inter-canine line and the posterior margin of the incisive papilla with gender ($t=0.14$, $p=0.89$), facial profile ($F=0.17$, $p= 0.68$), body type ($F=0.51$, $p= 0.61$). The distance between the posterior margin of the incisive papilla to the inter-canine line varied with the arch form ($F=3.40$, $p= 0.04$). The mean inter-canine width was 35.44±1.79mm. The inter-canine width was significantly higher among the males than the females ($t=2.68$, $p=0.008$). There was no variation in the inter-canine width with age (Pearson correlation=0.03, $p=0.75$), facial profile ($t=0.17$, $p= 0.86$) or body type ($F=0.86$, $p=0.43$). The inter-canine width for square arches was significantly higher than that of ovoid and tapering arches. There was a weak correlation between the inter-canine width and the distance from the inter-canine line to the most posterior limit of the incisive papilla ($r=-0.09$, $p=0.34$).There was a correlation between the inter-canine width and the distance from the posterior limit of the incisive papilla to the most labial aspect of the right maxillary central incisor. The distance from the posterior limit of the incisive papilla to the inter-canine line was correlated to the distance from the posterior limit of the incisive papilla to the most labial aspect of the 11 ($r=0.75$, $p< 0.05$).

Conclusion: The mean distance from the posterior margin of the incisive papilla to the most labial aspect of the maxillary central incisor was 14.93±1.52mm among Kenyans of African descent. This is different from findings among Caucasian populations. The mean distance from the posterior margin of the incisive papilla to the inter-canine line was 4.73±1.73mm. This finding contradicts the recommendation from Caucasian studies.

CHAPTER ONE

1.0 INTRODUCTION AND LITERATURE REVIEW

1.1 INTRODUCTION

Oral health is part of general health. Therefore, it is essential to general well being of an individual[1]. The oral health status of an individual affects his/her oral health related quality of life, and their life as a whole[2]. Several indices have been used to assess the oral health of populations, key among them being the loss of teeth[3].

Tooth loss remains a global burden despite improvements that have been recorded, mainly in the developed world[4]. The greatest burden of oral disease is on the less privileged and socially marginalized populations. This makes oral disease a bigger challenge in low and middle income countries, Kenya included[5]. The most common cause of tooth loss is extraction as a result of dental caries and periodontal disease[6]. Although both dental caries and periodontal disease are biologic disease processes, loss of teeth is often compounded by availability, accessibility and affordability of dental care[7]. Loss of all teeth leads to edentulism.

Edentulism is the terminal outcome of a multifactorial process involving biologic and non-biologic processes. It is associated with older age, having a low income, less education, being unmarried, having a less prestigious occupation and belonging to a minority group[8-10]. The prevalence of edentulism varies from country to country and even within the same country among different subsections of the population. There is no data available on the prevalence of edentulism in Kenya. Ngatia *et al* estimated it to be 2.5% among adults older than 45 years in Riruta and Waithaka locations in Dagoreti division , Nairobi in 2003[11].

Edentulism has a myriad of consequences. It is a serious emotional life event that is associated with challenges in mastication, poor facial aesthetics and difficulty in articulation of certain sounds. These problems usually cause the edentulous person to seek replacement for the lost teeth[10].

Complete denture prosthesis remain the most common modality of tooth replacement for edentulous persons. Complete denture treatment may present with challenges which including function, comfort and aesthetics[12,13]. With the use of dental implants, dentists are able to predictably address comfort and function in an increasing percentage[14]. Nevertheless, restoring the appearance of an edentulous patient remains problematic[15].

During construction of complete dentures, arrangement of artificial teeth is a critical stage. Tooth arrangement is more critical in the aesthetic zone, since complete denture aesthetics is key in patient satisfaction with complete denture treatment outcome[13,16-19] . The aesthetic appearance of a complete denture is affected by, among other factors, the denture base as well as the prosthetic teeth. The use of acrylic resin, which is easy to stain, has considerably enabled clinicians to improve the appearance of the denture base[15]. The main challenge in complete denture aesthetics is the appearance of the prosthetic teeth, which is determined by the tooth display, shape, size, proportion and their arrangement. Tooth arrangement is the major determinant of tooth-mold appearance and, therefore, more important to overall denture aesthetics[20-23]. Maxillary anterior teeth are mostly visible during speech and when the person smiles. The positions of the maxillary central incisors and canines are crucial in determining the aesthetics of complete dentures. Once the positions of these two teeth have been determined, the placement of other teeth may be made easier.

After tooth extraction, the alveolar bone undergoes resorption in a manner that makes it difficult to determine positions of the natural teeth[24]. The artificial teeth should be placed in the position of the lost natural teeth, although modifications may be necessary[25]. These positions are best determined using pre-extraction records such as casts[26,27]. Most persons who seek complete denture care in Kenya do not have pre-extraction records. In such situations, biometric guides have been recommended for determination of prosthetic tooth positions[28]. One of the most commonly used biometric guides in determining the positions of the maxillary central incisors and canines is the incisive papilla. The incisive papilla has been described as a stable landmark that remains relatively unchanged after anterior tooth extraction and subsequent resorption of the maxillary ridge[29]. Different researchers have studied the relationship between the posterior limit of the incisive papilla among different populations and come up with different estimates: Ehrlich and Gazit[30] reported a mean distance from the posterior limit of the incisive papilla to the labial aspect of the maxillary central incisor to be 12-13mm, similar to Grave and Becker[31], Lassila *et al*.[32] obtained 12.0mm, Ortman and Tsao[33] 12.454mm, Elinger[34] 12.3mm.

Mavroskoufis and Ritchie recommended that the canines should be set with their tips on a line passing through the posterior border of the incisive papilla[35]. Gove and Christensen found that in dentate subjects, a line joining the distal points of the canines lies 3mm posterior to the posterior limit of the incisive papilla[36].

There is variation in anatomy and general body structure between racial groups. Such variation should be considered when applying biometric guides to complete denture construction. The guidelines currently used to position maxillary canines and central incisors among Kenyans of African descent, with reference to the incisive papilla, are based on studies conducted among Caucasian populations.

From the aforementioned, it is clear that the guidelines currently available may not precisely apply to Kenyans of African descent, and who form the majority of persons seeking complete denture care in Kenya. Therefore, this study sought to describe the relationship between the incisive papilla and the maxillary canines and central incisors among Kenyans of African descent. It also sought to investigate the effects of age, gender, somatotype, arch from, and the facial profile of the individual on the relationship between the incisive papilla and the maxillary canines and central incisors. This information will contribute to scientific knowledge and also establish possible appropriate guidelines for the use of the incisive papilla as a biometric guide for arrangement of maxillary anterior teeth during complete denture construction. These guidelines would result to consistency and convenience in teaching and practice of complete denture construction which may also improve aesthetic outcome of complete denture treatment in the African population in Kenya. The findings from this study may also provide a baseline for further research.

1.2 LITERATURE REVIEW

1.2.1 Background information

There is an increasing acceptance that general health and oral health are related to the functional, psychological, social and aesthetic well-being of the person. The World Health Organisation recognises that oral health is integral to general health and essential for well being[1]. A person's oral health status can affect them physically and psychologically, and influence how they enjoy life; how they look, speak, chew, taste and enjoy food, socialise, as well as their self-esteem, self-image and feelings of social well-being[37.] Ideal dental appearance is attributed to a higher social class and intellect by younger and older individuals, a fact that stresses the undiminished importance of dental aesthetics among the elderly[3].Tooth loss has been used as an index to assess the oral health status of populations[3]. Studies have shown that more people are retaining their teeth as they advance in age and the prevalence of edentulism has declined over the last few decades in the developed world[38,39]. Despite these improvements in oral health, tooth loss still persists at a global level[4]. Major risk factors for oral disease are related to a cariogenic diet, improper oral hygiene measures, and limited availability, accessibility and affordability of oral health services[4].The greatest burden of oral diseases is on the disadvantaged and socially marginalized populations. This makes the burden of oral disease a greater challenge in low- and middle-income countries that do not yet have policies and resources to implement effective oral health programmes[5].

Dental caries and periodontal disease are the two most common dental diseases that if left untreated, eventually lead to tooth extraction[6]. Although the relative significance of these two diseases differ from region to region, caries stands as the most common reason for tooth extractions in most settings[6,40-42]. Caries has been found to relatively lead to more extractions among females than males, while periodontal disease leads to more extractions among older persons, more so among males[6].The other reasons why teeth may be extracted are: Prosthetic reasons, orthodontic reasons, trauma, cultural practices and as part of surgical resection necessitated by malignancies and cysts. Orthodontics is more important as a predominant reason for extraction before the age of 20[40,42,43].

1.2.2 Residual ridge resorption

After healing of the extraction wound, the residual alveolar bone undergoes life-long remodelling. Rapid reduction of the alveolar ridge occurs in the first 6 months, but bone resorption continues throughout life, albeit, at a slower rate, resulting in loss of greater volume of bone[24]. Residual ridge resorption is the term used for the diminishing quantity and quality of the residual ridge that occurs after teeth are removed[44.] It involves loss of volume, change in shape and loss of strength of the alveolar ridge[45]. During the middle life, the size and strength of bones remains nearly constant because bone formation and resorption are in balance. When this activity is not in balance, bone may gain size and strength due to more rapid apposition, as occurs during growth, or it may regress because of more rapid loss by resorption[45].

1.2.2.1 Factors associated with residual ridge resorption

No one factor appears to cause alveolar resorption, but a myriad of anatomic, metabolic, functional and prosthetic factors are involved[45,46]. Alveolar resorption is four times greater in the mandible than the maxilla. This is thought to be due to the smaller and less advantageous shape of the lower basal seat[47].

The anatomic factors involved include the quantity and quality of bone at baseline, and the blood supply[45,46]. A broad high ridge may have a greater potential of bone loss than a small ridge because there is more bone to be lost per unit time. The higher the density, the slower the rate of resorption because there is more bone to be resorbed per unit time[46].There is altered blood supply that may follow tooth extraction. Denture bearing bone receives blood supply from two sources, internal and external from the periosteum. If large amounts of alveolar bone are removed during surgical extraction, internal blood supply may be altered. The interference with blood supply leads to necrosis of bone. Inflammation that follows extraction may also cause increased internal capillary pressure which sets up resorptive processes[45].The shape of the mandible also has an effect on bone loss. Individuals with a marked mandibular base bend exhibit more bone loss than those with a flattened mandibular base. This may be due to stronger activity of the masseter and anterior temporal muscles in the former group[47].

The metabolic factors involved in bone resorption include metabolism of calcium and phosphorus, metabolism of protein, hormonal influences and the inherent potential of the individual[46]. The endocrine system has an effect on all body functions. Hormones affect protein synthesis as well as metabolism of key minerals involved in bone formation. The endocrine system, therefore, affects alveolar resorption[45].

Normal forces that stimulate bone formation are withdrawn when teeth are removed[46].Tissue disuse results in protein deficit followed by metabolic derangement. In bone, this leads to deficiency in formation of new matrix. This disuse atrophy appears in the alveolar bone as loss of alveolar bone around teeth with no opposing occlusion, edentulous spaces where several teeth have been lost, and completely edentulous mouths where total remodeling of the entire residual ridge occurs. Disuse atrophy does not result from direct loss of nonfunctional bone, but from lack of replacement of bone not needed for function[45].

The stress on local tissues caused by surgical trauma of an extraction has been blamed for alveolar resorption. Stress causes the anterior pituitary gland to release adrenocorticotropic hormone (ACTH). ACTH causes protein catabolism which interferes with the formation of bone matrix. Stress also causes a reduction in sex hormones which have a protein anabolic effect[45].There is a reduction in basal metabolism and the ability of tissue to regenerate and adapt with age. Age, therefore has an effect on alveolar resorption.

The intake and absorption of vitamins, minerals and proteins affects bone formation. The action of vitamins in many respects is the same as that of hormones. Protein is used in the formation of bone matrix, while minerals like calcium and phosphate from the mineralizing substance of bone[45].

The frequency, intensity, duration and the direction of force applied on bone affects cell activity[46]. Although evidence may be inconclusive, it appears that the denture base may either act to retard or to hasten the process of bone resorption. Mechanical factors designed into the denture by impression making, jaw relations records and occlusion should keep the pressure within tissue tolerance. If these forces are well controlled, the denture base may provide stimuli that retard resorption[45]. Prosthetic factors have been found to be difficult to evaluate due to the great number of variables involved[46].

Rapid resorption occurs during the first year of denture wearing followed by a gradual decrease to less than a tenth the initial rate thereafter. The magnitude and pattern of resorption shows great individual variation. Some mainly show vertical resorption while others display more horizontal bone loss[47]. In the anterior part of the jaws, the direction of resorption is commonly vertical and in a labiolingual direction. Posteriorly, the maxillary ridge undergoes vertical and buccopalatal resorption, while the mandibular ridge is resorbed in a mainly vertical direction[48].There is commonly a decrease in facial height caused by pronounced reduction in the mandibular ridge and consequent forward rotation of the mandible with long term denture wearing[47].

Different techniques of ridge augmentation have been used before to address inadequacy of alveolar ridge due to resorption. Some of these techniques that have been advocated for include onlay-inlay grafts, sandwich osteotomies, guided bone regeneration, piezoelectricity, alveolar distraction and crest-splitting bone expansion technique[49,50]. Sinus lifts in combination with platelet-rich plasma, autogenous bone and xenograft material have been used in atrophic maxillae[51]. However, all these technique have faced different risks and complications. Full ridge augmentation with autologous bone grafts have been attempted before complete denture restorations, but large volumes of loss commonly occur within a year or so postoperatively[52]. Compensation for resorbed ridges can also be done by increasing the volume of the denture base material. This may require making the maxillary denture base hollow to reduce the weight[53]. Mandibular overdenture stabilised with two implants has been advocated as first choice standard of care for edentulous persons[54].

Tooth loss is associated with a reduction in oral health related quality of life. However, the relationship between increasing tooth loss and severe impacts on oral health is not a simple one, and appears to be modifed by cultural factors. The position of the lost tooth on the arch is a key factor in the effects on the oral health related quality of life of the person[55]. A threshold of 20 teeth is widely used as a broad indicator of a functional dentition. This has been justified using clinical principles, and there is empirical evidence that this threshold is associated with functional and nutritional adequacy[56,57]. Although the evidence may not be conclusive, tooth loss has been associated with increased risk of upper gastrointestinal cancer, stroke and heart disease and even death[58]. Loss of all teeth leads to edentulism.

Edentulism is the terminal outcome of a multifactorial process involving biologic processes (caries, periodontal disease, pulpal pathology, trauma, oral cancer) as well as certain factors that compound the biologic processes(access to care, patient preferences, third party payments for selected procedures, treatment options among others)[7]. Edentulism is more common in disadvantaged populations, and is associated with older age, having a low income, less education, being unmarried, having a less prestigious occupation and belonging to a minority group[8-10].

1.2.3 The edentulous milieu

There is wide variation in the prevalence of edentulism between and within countries. The prevalence of edentulism is estimated to be 6.4% in Australia[59], with a wide variation of between 11-80% reported in different settings from various parts of Europe[38]. India and Mexico have reported a prevalence of 16.3-21.7%, while China, Ghana and South Africa reported 3.0-9%[60].

Although no national data are available on the incidence or prevalence of edentulism in Kenya, Ngatia *et al* estimated it to be 2.5% among adults older than 45 years in Riruta and Waithaka locations in Dagoreti division, Nairobi in 2003[11].

Edentulism has a myriad of consequences. It has been acknowledged by some authors that it is a serious emotional life issue, comparable to major life events such as loss of a limb or death of a family member[61]. Edentulous persons are more likely to feel less confident about themselves and more likely to feel inhibited in carrying out every day activities[62]. Edentulism is associated with feelings of insecurity, inferiority and considerable psychological problems[63]. There also occurs an inevitable change of facial shape following loss of teeth[62]. To most people, it is mutilating and provides a strong incentive to seek dental care to preserve and restore normal speech, masticatory function, and a socially acceptable appearance[10].

Studies indicate that oral health has an impact on food choice and on the intake of key nutrients, causing various nutritional problems[64]. Many edentulous individuals have difficulties in chewing and even when provided with optimal complete dentures, their masticatory efficiency remains much lower than those with natural teeth, fixed prosthesis, or with osseointegrated oral implants[65]. The reduced masticatory function causes the individual to choose foods that are predominantly soft and easy to chew, which may in turn induce poor dietary practices and marginal nutritional intakes[66].This affects the general health of the individual. Inadequate dental status and folate intake in the elderly has been reported to be independent predictors of mortality, at least in women[67].

1.2.4 History of tooth replacement.

Tooth replacement has been practiced by the Egyptians from about 2500 BC. The first mention of partial dentures was in 1711. These were curved from a block of hard wood, bone or ivory by measurement and fitting without use of impressions or casts, and fastened onto natural teeth using screws, gold wire or other means[68]. In 1700s, Pfaff described a method of introducing warm wax into the mouth and allowing it to set before withdrawing it to produce a negative replica of the patient's denture bearing oral tissues[69]. From this impression, a cast of plaster of Paris was generated. Research has led to development of new impression materials as well as denture base and prosthetic tooth materials that have revolutionized prosthetic care over the years.

The French dentist Erienne Bourdet (1775) made the first reference to use of gold as a denture base material. Gold was the first metallic denture base material. The golden base had small holes like sockets into which ivory or natural teeth were attached. Initially the gold did not fit well onto the ridge, but after development of impression techniques using softened wax or plaster of Paris, hammering and swaging enabled achievement of better adaptation onto casts. Gold (18 or 20 carat) was alloyed with silver and teeth attached by riveting[70]. In 1788, the Parisian dentist Nicholas Dubois De Chemant teamed up with apothecary Alexis Duchateau and developed a baked porcelain complete denture in one block. Porcelain replaced the animal substances for use as denture base material for some time.

Charles Goodyear developed vulcanite for use as a denture base material around 1839, which was used with porcelain teeth to provide complete dentures for edentulous patients[71]. The disadvantages of vulcanite were poor aesthetics, difficulty in pigmentation and easy contamination with absorption of saliva[72].

Alfred Blandy introduced a low fusing alloy of silver, bismuth and antimony in 1856, another attempt at metallic denture base .Dentures made from this material were called cheoplastic dentures. This was not widely accepted, but the method of molding was adapted for use with vulcanite. In 1867, Dr Bean invented the casting machine and made the first cast metallic denture base of aluminum. The fit made aluminum the material of choice, but cost of fabrication, difficulty in relining and potential relationship between aluminum and Alzheimer's disease discouraged the use of aluminum and its alloys[73].

Celluloid was then developed in 1868 by John Wesley Hyatt[74-76]. It was aesthetically superior to vulcanite but discoloured and stained easily. The taste was not pleasant and the dentures warped in service[77-82]. Charles Land made dentures from platinum base in 1890. In 1907, Dr. Leo Bakeland developed Bakelite[68]. The dentures made from Bakelite lacked uniformity and it was not possible to control physical properties which depended on processing conditions. It was also brittle, very stiff and difficult to mould[79,81,83-85]. It was impossible to repair, easily discoloured and retained the taste of phenol. The polymerization was affected by water[78].

Use of stainless steel, silver and its alloys then followed. Base metal alloys, mainly Ni-Cr and Co- Cr, have currently replaced gold and aluminum alloys as metallic denture base materials. These base metal alloys were obtained by Elwood Haynes in 1907, but it was not until 1937 that materials and techniques for the use of these materials were perfected.

Vinyl polymers were then developed after 1932[80]. Although the aesthetics was good, the processing was technique sensitive and often caused warping and fracture in service[78]. Modifications of vinyl polymers were introduced in 1939[81-87].These showed high fatigue resistance, little water absorption, and high impact strength[79,88-90]. However, they had low elastic modulus and low transition temperature, which could lead to distortion while cleaning or polishing at high temperature[89,91].

Epoxy resins were first synthesized in 1937 by Pierre Casten[92]. They were tough, strong, hard with low curing shrinkage and good adhesion to metals[93-95].The disadvantages were toxicity of some of the curing agents[79,81,96], discolouration[93,95,97], high water sorption[78,80] and poor bonding to prosthetic teeth[95].

High impact polystyrene (Jetron) was introduced for denture base construction in 1951. It had low water sorption[88,89]. However, midline fractures were common in maxillary dentures and the reproduction of impression surface was poor[98,99].

Nylon was tried in 1950s as a flexible denture base material[100,101]. The strength was good[102], but the high moulding shrinkage, high water sorption and discolouration made it undesirable[79,82,95]. It had poor flexibility and poor chemical union with prosthetic teeth. It was also difficult to polish[78,87].

Polycarbonates were then tried, but were not widely used because their use required complex instruments and because of high incidence of denture cracks. Use of polycarbonates as denture base is limited to porcelain prosthetic teeth because of its high moulding temperature[89].

Poly(Methyl Methacryate) (PMMA) was introduced in 1937 by Dr Walter Wright[68]. It has since become the most popular complete denture base as well as prosthetic tooth material because of its favourable, though less than ideal properties[103]. These including ease of processing, pigmentability, attainable high polish, adequate strength, ease of repair, low water sorption, low solubility, relatively low toxicity, tasteless and oduorless. However, the undesirable properties of PMMA are large polymerization shrinkage, high thermal expansion co-efficient, radiolucency and allergy among a section of the population[78]. Improvements on PMMA have led to the development of high impact acrylic and visible L.C acrylic. There have been attempts to develop alternative denture base materials with better properties than PMMA, including polysulphones and pure titanium, but all have been unsuccessful[104-106].

1.2.4.1 History of artificial tooth material

The earliest mention of complete denture use is in Japan in the early sixteenth century. These dentures were curved from sweet-smelling wood such as apricot, cherry, or boxwood. Most of these prosthesis had the teeth curved from the same block as the base, while others had teeth from ivory, bone or human teeth[107,108]. Pierre Fauchard used the same tooth materials with metal bases to make dentures retained by steel springs[109].He realised that these organic materials deteriorated in the oral environment and elicited a horrific taste and oduor. He attempted the use of jewelers enamel to teeth made from thin gold plate[110,111]. In the late 16th century, a material composed of white, granulated wax, olive tree resin, matrix powder, and finely ground choral pearl was attempted as artificial tooth material without success[108]. The next major milestone in provision of artificial teeth was the development of porcelain teeth by a French apothecary collaborating with a dentist. These porcelain teeth were in one block[112]. In 1808, an Italian dentist Guiseppangeio Fonzi introduced individually baked porcelain teeth, called the French bean teeth. A platinum hook was attached to each porcelain tooth. The hook was soldered to a gold denture base[113]. Human teeth were used alongside porcelain teeth for the better part of the nineteenth century. In 1837, a London goldsmith Claudius Ash improved on the French bean teeth and began manufacture of mineral teeth in several shades of gray[108]. Posterior teeth provided during this time had very crude occlusal anatomy and as such, there was no difference between left from right, mandibular from maxillary, molars from premolars[114]. Acrylic resin was introduced in 1950s and has been applied widely in dentistry including as denture teeth material[115]. Composite resins were introduced in 1980s as suitable material for fabrication of denture teeth[116].

1.2.5 Challenges in complete denture construction.

Despite the much value that complete denture service has added to the lives of edentulous persons, the treatment challenges of such patients have been described as a combination of function, comfort and aesthetics[12,13]. The function and comfort of complete dentures can greatly be improved by use of dental implants for denture stabilization[14]. Comfort and function are, therefore, no longer beyond the dentist's ability to predictably address in an increasing percentage of the edentulous population. In contrast, restoring an edentulous patient's appearance has received little attention in modern prosthodontic literature[15].

Complete denture aesthetics has been found to be key in patient satisfaction with complete denture treatment outcome. Carlson *et al* found aesthetics to be the most responsible factor for complete denture success[13]. Both the patient and the observer conception of the aesthetic result were found to be highly significant. Several other studies have similarly established that aesthetics is the most significant factor in complete denture treatment success[16-19]. Lefer *et al* had statistically significant fewer adjustment appointments and a greater number of pleased patients when all the aesthetic decisions were made by the patient[19]. If the dentist understands what the patient prefers, the chances of miscommunication are likely to be decreased[117]. Vig emphasized the importance of aesthetics in complete denture treatment outcome when he stated that good appearance is so related psychologically to comfort that the two cannot be separated[118].

Successful aesthetic outcome may, therefore, be directly related to the overall treatment success. Fisher stated the aesthetic objectives that must be achieved by the dentist as to lift the patient out of the category of a geometric figure and restore to him his true quality of a living and breathing man or woman, with an individual personality and either the dignity of his years or the freshness of his youth[119]. The dental profession, therefore, has a huge burden to deliver aesthetic complete denture prosthesis. Despite the fact that solutions to functional and comfort-related problems are available, successfully restoring the appearance of an edentulous patient remains problematic[15].

A dental prosthesis provides support, function and aesthetics. In order to achieve this and be aesthetically acceptable, the restoration should blend with the facial profile and help to establish part of it. Although clinical judgment is invaluable, a method of making systematic analysis of tooth position, tooth inclination to the face and oral structures would aid, especially for nearly or completely edentulous patient[120].

The smile line determines how much tooth material is visible when a person smiles. Aesthetic appearance of a complete denture is generally affected by the denture base as well as the prosthetic teeth[118]. The smile line and, therefore, the degree of anterior tooth display varies depending on gender, race, lip fullness, age, and upper lip length[120,121]. Women display twice as much maxillary anterior tooth surface as men, while men display more mandibular incisor tooth material than the women. The shorter the upper lip the more the degree of tooth display and vice versa. There is generally a gradual decrease in display of maxillary anterior teeth with age, with a corresponding increase in the display of mandibular anterior teeth[118].

The use of acrylic resin, which is easy to stain, has considerably enabled clinicians to improve the appearance of the denture base[15]. The denture base appearance is, therefore, less a challenge for the dental profession. The main challenge in complete denture aesthetics remains the appearance of the prosthetic teeth. The aesthetic appearance of the teeth in complete dentures is determined by the tooth display, shape, size, proportion and arrangement. Nelson asserted that tooth arrangement was the major determinant of tooth-mold appearance and, therefore, more important to overall denture aesthetics[20-23].

Where there has been a reasonably short time between extractions and the denture construction, and the person is relatively young, there is usually considerable residual bone. In such situations, it is recommended that the teeth are replaced in their original anatomical positions where the natural teeth used to be[25]. However, prolonged edentulism leads to resorption of the alveolar bone in complex patterns. In such cases, placing denture teeth in the original location of the crest of the ridge before it was resorbed causes instability of the denture and discomfort for the patient[122]. Modifications to the original positions of the teeth may thus be required while setting the prosthetic teeth.

1.2.6 Pre-extraction records.

During complete denture construction, establishing the vertical dimension of occlusion, recording centric relation and arranging maxillary anterior teeth in the right positions are vital in treatment success[123]. Without any pre-extraction records, the dentist relies on factors which are subject to many variables and which require considerable clinical judgment to establish these important details of the denture. This judgment requires some clinical experience[124]. Pre-extraction records have been proposed to help overcome these challenges[26,27,125]. The most commonly used pre-extraction records include pre-extraction diagnostic casts, profile photographs, and radiographs[126]. Although pre-extraction records have been recommended for the various purposes, they have been found more useful for the determination of vertical dimension of occlusion and arranging maxillary anterior teeth, and less useful for recording the centric relation[126]. Clinicians have, however, raised concerns about the recording and storage of pre-extraction records. A good number find recording, storage and preservation of these records tedious, time consuming and an extra burden[127]. Similar reasons may be behind scarce availability of these records for most persons seeking complete denture care in Kenya. Without pre-extraction records, the systematic approach required in this process may be achieved to some degree through the use of biometric guides[28].

1.2.7 Biometric guides.

Several intra-oral and extra-oral biometric guides have been proposed to aid in the selection and arrangement of artificial teeth in complete denture construction. These include nasal width, the remnant of the palatal-gingival margin, inner canthi of the eyes, the bias-corrected measurement from the left hamular notch mark to the right hamular notch mark, inter-alar, inter-commisural, bizygomatic and philtrum widths, saggital cranial diameter, inter-canthal width, and the inter-buccal frenum distance[128-130].

Studies have found no demonstrable relationship between interalar width of the nose and the total width of the four maxillary incisors[35]. Reports on the relationship between inter-alar width and inter-canine width are conflicting, with some studies saying there is a relationship and others there saying there isn't[35,131] .

The palatal gingival margin is the remnant of the gingival margin on the palatal side of the dental arch, which after tooth extraction often remains visible as a cordlike elevation. It has been recommended as a landmark for estimating the pre-extraction dimensions of the ridge. For an edentulous jaw, it is situated near the crest of the ridge[132].

The tip of the philtrum of the upper lip can be used to locate the maxillary dental midline[133]. Scandrett *et al* found inter-commisural width, interalar width, inter-buccal frenum width, saggital cranial diameter, width of the philtrum (superior), width of the philtrum (inferior), and bi-zygomatic width all significantly correlated to the width of the maxillary anterior teeth. However, all the standard of errors of prediction were too large to justify use of any of these alone, therefore, they suggested the use of two or more of the predictor variables to determine the width of the maxillary anterior teeth and the width of the maxillary central incisor[130].

A line joining the anterior nasal spine and the hamular notch (Cook's plane) has been found to form a predictable angle with the occlusal plane. The angle formed between Cook's plane and the occlusal plane is related to the distance between the anterior nasal spine and the hamular notch, and the greater this distance the more acute the angle, the shorter the distance the more obtuse the angle[134].

A ratio of 1:0.267 has been found between the inter-canthal width and the maxillary central incisor width. The ratio between the inter-canthal width and the combined mesio-distal widths of the 6 maxillary anterior teeth was approximately 1:1.426[28].

Panjwani *et al* examined the use of the palatal rugae in establishing anterior maxillary arch geometry and tooth positions and found significant correlation between the length of the third palatal rugae and the width of the anterior dental segment (distance between central grooves of the left and right maxillary premolars).The study suggests the use of the rugae as a guide to determine the position of the maxillary central incisors and first premolars. The correlation values were, however, too weak to be of clinical significance[135].

1.2.8 The use of the incisive papilla.

The incisive papilla is one of the most commonly used biometric guides in the selection and setting of anterior teeth. The incisive papilla is a pear-shaped prominence on the hard palate that lies at the anterior extremity of the mid-palatine raphe. It is devoid of the submucosa and covers the incisive fossa at the oral opening of the incisive canal and also marks the position of the fetal nasopalatine canal[136]. It covers the nasopalatine nerve and blood vessels[137]. The incisive papilla has been described as a stable landmark that remains relatively unchanged after anterior tooth extraction and subsequent resorption of the maxillary ridge[29]. Although its accuracy has been questioned by some authors[25], it may serve some purpose because it is an easy reference to make[138]. The position of the incisive papilla related to the crest of the ridge reflects the amount of bone resorption in the sagittal dimension[125]. It has been recommended for assessment of the original positions of certain key teeth as well as estimation of the display of the maxillary anterior teeth at rest and in full smile[120,139]. The anterior part of the papilla may be damaged or affected during tooth extraction or during resorption that follows tooth loss. The centre or posterior margins are, therefore, more constant and reliable for use as a reference[29]. Watt and Likeman observed that as a result of alveolar ridge resorption, the papilla moved forward about 1.6mm. This changes the relationship between incisive papilla and the incisive fossa. To compensate for this alteration, they recommended the use of the posterior border of the incisive papilla while positioning the maxillary canines with reference as the coronal plane[25]. Watt observed that in dentate mouths, the inter-canine line passes through the middle of the incisive papilla in the coronal plane. After tooth loss, he recommended that the canine tips be positioned in a coronal plane passing through the posterior border of the incisive papilla[122]. The posterior margin of the incisive papilla can be identified quickly, easily and with more accuracy, than the center of the papilla. Central incisors and canines are key in incising, aesthetics, speech, lip support and providing harmonious anterior guidance. Hickey *et al* suggested that the labial surface of the central incisors should be 8-10 mm from a line that passes in the middle of the incisive papilla from left to right[138].

Mavroskoufis and Ritchie reaffirmed the use of the incisive papilla as a reliable and relatively stable anatomical landmark[35]. To identify canine tips, they placed pins on hydrocolloid impressions prior to generation of casts. The casts were inverted onto a white paper over a cork board to make perforations. A third perforation was made with a pin held perpendicularly and in contact with the maximum convexity of the incisors. They found the mean inter-canine width to be 34.3mm. The inter-canine line was within 0.6mm from the middle of the incisive papilla. The middle of the incisive papilla was a mean of 10.2 mm from the greatest convexity of the labial surface of the central incisors. The sample was drawn from a Caucasian population of dental students.

Sawiris[140] studied the relationship between the incisive papilla, maxillary canines, and maxillary central incisor among British Caucasians. He compared these relationships among dentate subjects of mean age of 25.86 years, to that among complete denture wearers. The first group of denture wearers (mean age of 59.94 years) had their dentures made by dental students, while the second group (mean age 63.08 years) had their dentures made by dental practitioners. The mean inter-canine width among the dentate group was 34.48mm. The mean distance from the centre of the incisive papilla to the mesio-incisal point among dentate subjects was 8.56mm. The inter-canine line passed ±1mm from the centre of the incisive papilla. The measurements from dentures made by students were comparable to those from dentate subjects while the measurements from dentures made by dental practitioners were significantly smaller.

Grave and Becker[31] compared the relationship between the posterior margin of the incisive papilla and the left maxillary central incisor among dentate individuals and complete denture wearers. Both groups were comprised of Caucasian adults of unspecified age. The measurement on dentures was done directly from the dentures with the measuring gauge suspended on a surveyor, and the occlusal surfaces of the denture teeth resting on the stage of the surveyor. Casts were generated from hydrocolloid impressions taken from the dentate subjects. The bases of the casts were trimmed parallel to the occlusal surface. The casts were then inverted on the stage of the surveyor, with the occlusal aspect facing upwards and the measurement made with the gauge suspended on the surveyor. They found that the distance from the posterior margin of the incisive papilla to the labial surface of the central incisor was 12-13mm, and that the central incisors were commonly placed too far posterior in dentures.

Lassila *et al*[32] studied the relationship between the incisive papilla among post-menopausal women aged 48-56 years. The racial profile of the subjects were undisclosed, but given the study was carried out in Finland, it is likely they were Caucasian. The distance from the posterior border of the incisive papilla was 12.08±1.18mm. The inter-canine line passed very near the posterior margin of the incisive papilla.

Ortman and Tsao[33] examined the relationship between the posterior margin of the incisive papilla and the most anterior point of maxillary central incisors among students of unspecified age, race and gender. This study was conducted at the State University of New York at Buffallo. They generated casts from irreversible hydrocolloid impressions, and used a jig to orient the casts. A profile projection measure composed of a set of lenses was used to carry out the measurements. The mean distance from the most anterior point of the maxillary central incisors to the posterior border of the incisive papilla was 12.454±3.867mm.

Elinger[34] studied the relationship between the distal margin of the incisive papilla and the labial surface of maxillary central incisor among Caucasian men and women aged 21-62 years. He placed radiopaque paste on the mucosa at the distal border of the papilla before exposing lateral cephalometric roentgenograms. Cephalometric tracings and measurements established the distance to have been 12.3±1.2mm (Range=10.0-15.9mm).

Grove and Christensen[36] measured the orthographic anteroposterior distance between the posterior border of the incisive papilla and a line drawn between the distal contacts of the maxillary canines. They used casts generated from irreversible hydrocolloid impressions, with the occlusal plane as the reference plane. The subjects were Caucasian men and women aged between 12 and 52 years, with a median age of 25 years. They used a contour meter to orient and measure the casts in a three-dimensional coordinate system. The posterior limit of the incisive papilla was 2.695±1.745mm anterior to the line joining the distal points of the canines. No gender, age and arch form differences were noted.

Schiffman[141] found the intercanine axis to have been ±1mm from the centre of the papilla among a Caucasian population.

Ehrlich and Gazit[30] investigated the relationship between incisive papilla and maxillary canines and central incisors among Caucasian men and women aged 17-35 years. The inter-canine distance was measured directly from the casts using calipers. The relationship between the incisive papilla and the inter-canine line was established by placing a ruler against the canine tips and projecting a vertical line with a pin to the papilla. The center of the papilla was established by measuring its length and halving it. The casts were categorized according to the form of the dental arch as ovoid, square or tapering. Sixty four percent (64%), 25.6% and 10% of arches were ovoid, square and tapering respectively. The mean inter-canine width was 34.66(33.04-35.67) mm. In the ovoid and tapering arches the inter-canine line passed predominantly through the centre of the papilla or 1-3 mm posteriorly to the centre of the papilla. In the square arches the inter-canine line passed either through the centre of the papilla or 1-2 mm anterior to the centre of the papilla. The mean distance from the posterior margin of the incisive papilla to the labial surfaces of the central incisors was 12.31mm (range 12-13.21mm).

Tooth positions may thus differ with arch form. There has been observed associations between body type (somatotype), facial profile and the arch form. Endomorphs commonly have narrow dental arches while ectomorphs commonly have large square dental arches. Mesomorphs have normal sized dental arches[142].

Age is an independent risk factor for tooth loss and edentulism. The incidence of edentulism sharply increases from the age of fifty[143,144]. This causes the majority of persons who seek complete denture services to be relatively older. With life expectancy rising globally, the population of older people is projected to rise significantly, and with this the mean age of edentulous persons may rise as well[145]. Complete denture wearers may, therefore get older in future. There is a decrease in tooth sizes with age, a factor attributed to interproximal wear and loss of tooth structure at the incisal edge through attrition and abrasion. How this change affects the relationship between these teeth and the incisive papilla is unknown. The appearance of teeth has been found to be less important for older people, as compared to younger individuals[146]. This is thought to be contributed to by a number of factors. First, older people are more likely to develop more serious health problems which may outweigh perceived dental appearance and reduce the issue of dental appearance[147]. Secondly, older people may be happier looking similar to their peers due to peer group pressure within the age stratum[148]. Thirdly, it has been argued that self-concept and self-esteem are more developed and easier to protect in older people[147]. Thus older people may be more accepting of poorer dental appearance in cooperated in their self-image than younger persons. It is interesting that older persons, both men and women, who are concerned with their dental aesthetics prefer a more youthful appearance[148]. Observations made from a youthful population, like the current study, may therefore be applicable across all ages. Facial and dental changes occur in adulthood. These changes are, however, relatively small in magnitude. Increased crowding occurs with age on both the mandibular and the maxillary arches, increasing the tooth- size arch length discrepancy. These changes are part of normal maturation process[149]. Tooth surface loss increases in prevalence and severity with age[150]. This would make identification of certain morphological features difficult. Change in tooth positions to compensate for tooth surface loss may also affect the outcome of this study, therefore, the young adult age group (18-35 years) was used in the study.

1.3 STATEMENT OF THE PROBLEM, STUDY JUSTIFICATION, OBJECTIVES, HYPOTHESIS AND VARIABLES

1.3.1 Problem Statement

The relationship between the incisive papilla and the maxillary anterior teeth has been described for some racial groups, including Caucasian and Mongoloid populations. Due to variations in anthropometric features between racial people groups, this relationship may be different among Kenyans of African descent. No data are available on the relationship between the incisive papilla and the maxillary anterior teeth among Kenyans of African descent. This study seeks to establish the facial profile, arch form pattern, body type, inter-canine width of the participants. Also to determine and describe any association between the incisive papilla and the maxillary anterior teeth among Kenyans of African descent.

1.3.2 Justification of Study

There is no study which has been done in Kenya to describe the relationship between the incisive papilla and the maxillary anterior teeth among Kenyans of African descent. It is therefore hoped that the findings from this study would contribute to scientific knowledge and also establish possible appropriate guidelines for the use of the incisive papilla as a biometric guide for arrangement of maxillary anterior teeth during complete denture construction. These guide lines would result to consistency and convenience in teaching and practice of complete denture construction which may also improve aesthetic outcome of complete denture treatment in the African population in Kenya. It is hoped that the findings from this study may also provide a baseline for further research.

1.3.3 OBJECTIVES

1.3.3.1 General Objective:

To determine the relationship between the incisive papilla and the maxillary anterior teeth among Kenyans of African descent.

1.3.3.2 Specific Objectives:

1. To determine the distance between the posterior margin of the incisive papilla and the most labial point of the maxillary central incisor among Kenyans of African descent.
2. To determine the distance between the posterior margin of the incisive papilla and the inter-canine line among Kenyans of African descent.
3. To compare the distance between the posterior limit of the incisive papilla and the most labial point of the maxillary central incisor among Kenyans of African descent to that described among Caucasian populations.
4. To describe the effects of age, gender, arch form and body type on; the distance from the posterior margin of the incisive papilla to the most labial point of the maxillary central incisor, and, the distance from the posterior margin of the incisive papilla to the inter-canine line, among Kenyans of African descent.

1.3.4 HYPOTHESIS

1.3.4.1 Null Hypothesis

There is no variation in the relationship between the posterior limit of the incisive papilla and the maxillary central incisors and inter-canine line, between Kenyans of African descent and Caucasian populations.

1.3.4.2 Alternate Hypothesis

There is variation in the relationship between the posterior limit of the incisive papilla and the maxillary central incisors and inter-canines line, between Kenyans of African descent and Caucasian populations.

1.3.5: VARIABLES

1.3.5.1: Independent variables

1. Age
2. Gender

1.3.5.2: Dependant variables

1. Arch form.
2. Body type.
3. Facial profile pattern(s).
4. The inter-canine width.
5. The distance from the posterior margin of the incisive papilla to the most labial aspect of the right maxillary central incisor.

CHAPTER TWO

2.0 MATERIALS AND METHODS

2.1 Study Design

This was a descriptive cross-sectional study which was conducted over a period of six months.

2.2 Study Population

2.2.1 Description of the study population

The study population was undergraduate and postgraduate students of the University of Nairobi (UoN), College of Health Sciences (CHS) aged between 18 and 35 years. The UoN is a public University that admits its students from every part of the Country through a free and fair process on basis of merit. The student population was assumed to be a representative sample of ethnic diversity of the Country. The researcher approached the students in the lecture theatres and introduced himself requesting volunteers to present themselves at the School of Dental Sciences, UoN for dental checkup and screening after ethical clearance. Those who met the inclusion criteria and consented were enrolled in the study.

2.2.2 Inclusion Criteria

a. Kenyans of African descent aged between 18 and 35 years.
b. Registered student of the CHS of the UoN.
c. Well aligned maxillary full arch up to the second molars.
d. Angle's Class 1 molar relationship.
e. Persons showing no tooth surface loss on the maxillary anterior teeth.

2.2.3 Exclusion Criteria

a. International students studying at CHS, UON.

b. Kenyans of non-African descent.

c. Persons with history of orthodontic treatment.

d. Persons with crowding in the maxillary anterior segment.

e. Persons with evidence of drifting and/or migration in the maxillary anterior segment.

f. Persons with any proximal restorations in the maxillary anterior segment.

g. Persons with tooth surface loss in the maxillary anterior segment.

h. Persons with any developmental defect or acquired pathology affecting the anterior maxilla.

i. Persons with any maxillary missing teeth. Persons missing the last molars were accepted into the study.

2.3 Sampling Method

A verbal appeal was issued by the investigator to the undergraduate and postgraduate students of UoN, CHS in the lecture halls. All the students who presented themselves at School of Dental Sciences, UoN, were briefed about the study by the investigator. The students were given oral hygiene instructions, dietary counseling and oral examination. The students who needed dental treatment were referred to the UoN Dental Hospital. The students of African descent were requested to prove Kenyan citizenship by producing the national identity card or passport. They were interviewed by the investigator to establish that they were of Kenyan descent. The students who did not meet the inclusion criteria were appreciated verbally and discharged. All the students who met the inclusion criteria were requested to read and sign the consent form in a language of their preference (English or Kiswahili). Those who met the inclusion criteria and signed the consent were enrolled into the study. The students were consecutively recruited into the study to a sample size of 112. The age, gender and facial profile of each subject was recorded onto an interviewer administered semi-structured questionnaire (Appendix I).

2.4 Sample Size Determination

Altman's monographs for calculation of sample size were used to calculate the sample size[151] (Fig. 2.1). A sample of 130 participants was arrived at. One hundred and twelve participants participated in the study, more than 75% of the calculated sample size.

Standardized difference. Power.

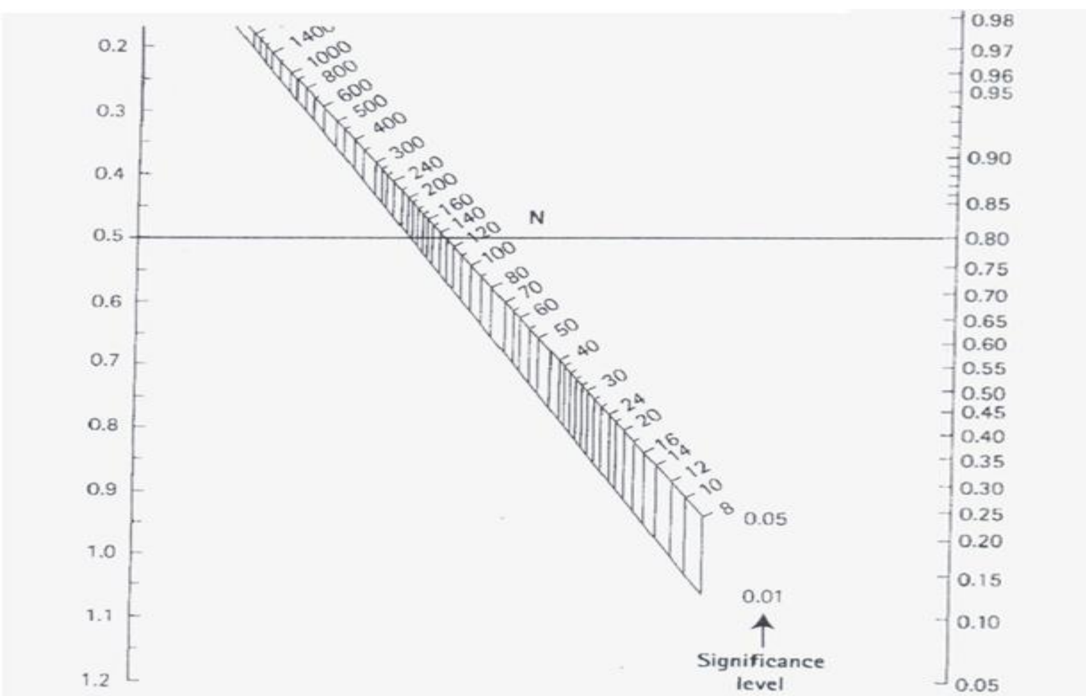


Fig 2.1: Altman's monograph for the calculation of sample size.

2.5 Ethical Considerations

a. Ethical approval was obtained from the Kenyatta National Hospital/UON Ethics and Research Committee (Ref No KNH-ERC/A/108 (Appendix III).

b. Permission was obtained from the relevant authorities of UON.

c. Informed consent was obtained from participants before they enrolled in the study (Appendix II).

d. Participants were at liberty to withdraw from the study at any point without victimization.

2.6 Data Collection

All the consenting students who met the inclusion criteria after the interview and oral examination were enrolled into the study. An interviewer administered questionnaire was administered by the investigator to capture the participants' age, gender, body type and facial profile.

2.6.1 Determination of facial profile and somatotype

Each subject was instructed to stand upright and place his/her head in the physiologic natural head position looking at the horizon. With the head in this position, the relationship between two lines was noted; one line dropped from the bridge of the nose to the base of the upper lip and a second one extending downward to the chin. The profile was judged as straight if the three points were on a straight line, convex if the middle point (base of upper lip) was anterior to the two other points and concave when the middle point was posterior to the other two points[152]. The somatotype was categorized by the investigator based on the general body build of the subject as ectomorphic (tall and thin), mesomorphic (average) and endomorphic (short and fat)[153]. The facial profile and the somatotype was entered onto the data collection sheet.

2.6.2 Impression making.

The researcher inspected the size of the maxillary arch and selected the appropriate size of perforated metallic stock tray (GC Europe, Leuven, Belgium). The stock tray was inserted into the mouth to confirm participant comfort and coverage of the teeth and associated soft tissues. Every participant rinsed his/her mouth with cold (room temperature) tap water before impression taking. Irreversible hydrocolloid (Blueprint® 20+, Dentsply Detrey GmbH, Konstanz Germany, batch no. 1207151573) was hand mixed vigorously in a bowl as per the manufacturer's instruction and loaded onto the tray then seated into the mouth to make impressions of maxillary arches. Upon setting the impression was withdrawn. The manufacturer's recommended setting time were observed. The participants were allowed to rinse their mouths after impression taking.

2.6.3 Impression processing and image capture

The impressions were rinsed thoroughly under cold running water to remove any debris, then disinfected by immersion in Zeta 7 solution (Zhermack® clinical, Badia Polesine, Italy) according to the manufacturer's instruction. The impressions were then wrapped in wet napkins and stored in zip-lock polythene bags to minimise dimensional changes. Type IV gypsum (Kaldent by Kalabhai, Mumbai, India, batch no. 121001) was used to pour the impressions within 15 minutes of impression taking under vibration to generate casts. The manufacturer's instructions were followed during manipulation of gypsum. The casts generated were trimmed using a model trimmer (Manfredi, Dentalcon Trading Ltd, Nicosia – Cyprus) under wet conditions, bench dried and stored in polythene bags in a dry environment.

The casts were evaluated for details by the investigator. The arch form was categorized as ovoid, tapering and square depending on the individual arch shape[154].The tip of the canine, the most posterior point of the incisive papilla and the most labial aspect of the maxillary right central incisor were identified on the casts and marked using a marker pen with a fine point (1.0mm tip diameter, Guangdong Baoke stationary co, LTD, Guangdon, China.). A photocopy of each cast was made using a photocopier (Kyocera Corporation, Kyoto, Japan.) to generate an image of the occlusal surfaces of the teeth in one plane at a ratio of 1:1 (the occlusal plane was used as the reference plane).

The position of the casts on the photocopier was standardized by placing cello tape to form a square frame, within which each cast was placed facing the same direction. Each cast was placed with the occlusal surface downwards, resting on the photocopier. On each photocopy, the tips of the canines were joined with a straight line (the inter-canine line). Lines parallel to the inter-canine line were drawn passing through the most posterior margin of the incisive papilla and the most labial aspect of the right maxillary central incisor. A perpendicular line joining these three lines was drawn to allow measurement of the distance between the lines. The same fine point pencil (Push 0.7, Pelikan, Schindellegi, Switzerland), which does not require sharpening, was used to draw all the lines for standardization on the thickness of the lines. (Figs 2.2 and 2.3):

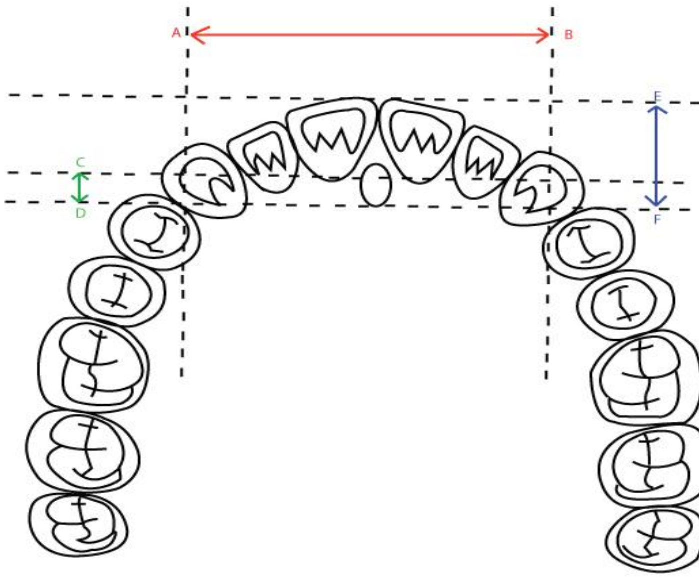


Fig 2.2: Schematic diagram of a photocopy of a cast and the measurements recorded.

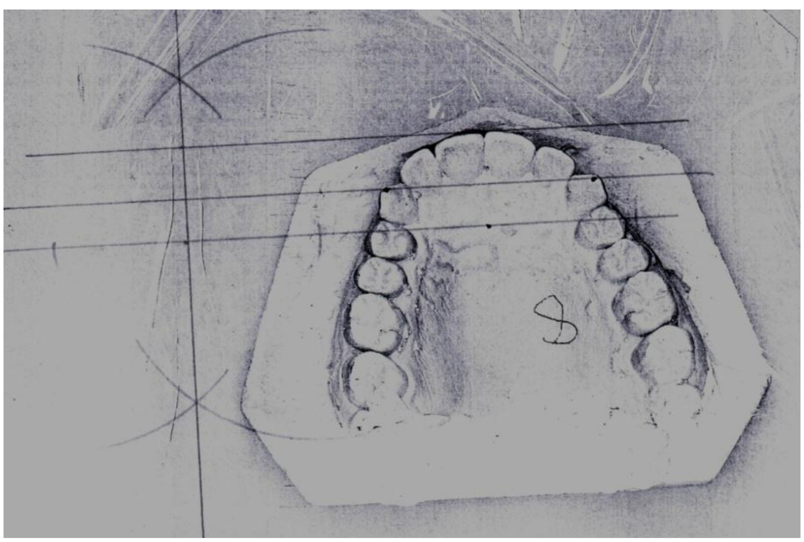


Fig 2.3: A sample of a photocopy of a cast.

2.6.4 Measurements

The following measurements were obtained from each photocopy using a digital caliper (CEN-TECH, Model 47256, Calabasas, CA) to the nearest 0.01 mm.

a. The distance between the cusp tips of the canines (inter-canine width).

b. The distance between the line joining the canine cusp tips and the tangent to the posterior margin of the incisive papilla.

c. The distance from the posterior margin of the incisive papilla and the most labial aspect of the right maxillary central incisor.

All the measurements were repeated thrice on three separate occasions, and the mean of the sum of the three taken as the correct measurement. The data was entered into a specially designed chart.

2.6.5 Data entry

The data collected and the measurements taken were entered into SPSS version 17 (SPSS Inc., Chicago IL).

2.6.6 Data analysis.

The data was analysed using statistical package for social sciences (SPSS) Version 17(SPSS Inc., Chicago IL). Description of the data collected was done, and association between the variables tested using chi square test, t- test, ANOVA and correlation. The results were compared with those obtained among Caucasian and Chinese populations.

2.7 Minimisation of Errors

To minimize errors, Alginate and gypsum materials from the same batch were used for all the impressions and casts (batch numbers 1207151573 and 121001 for alginate and gypsum respectively were used). The investigator was calibrated by the primary supervisor. The casts were evaluated for details by the researcher.

2.7.1 Intra-Examiner Variability

The investigator repeated measurements of inter-canine width and posterior limit of incisive papilla to the inter-canine line on two different occasions. The readings were compared using the intra-rator correlation co-efficient (Table 2.1, Fig 2.4). It was concluded that the readings from investigator were acceptably reproducible.

Table 2.1: Limits of agreement: Intra-rater reliability.

	Lower limit	Mean difference	Upper limit
Inter-canine width	-0.36	-0.18	0.00
Posterior limit of incisive papilla to inter-canine line.	-0.35	-0.15	0.05

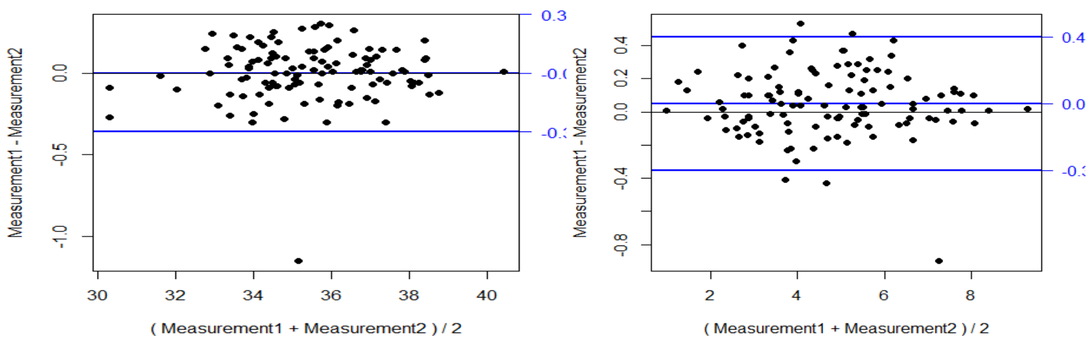


Fig 2.4: Bland Altman plot of difference between the scores vs mean of the scores of investigator.

2.7.2 Inter-Examiner Variability

The primary supervisor repeated evaluation and measurement of every tenth cast. The readings from the supervisor were compared to those from the investigator using the inter-rator correlation co-efficient (Fig 2.5, Table 2.2). It was concluded that the readings from investigator were acceptably accurate, and usable for further analysis.

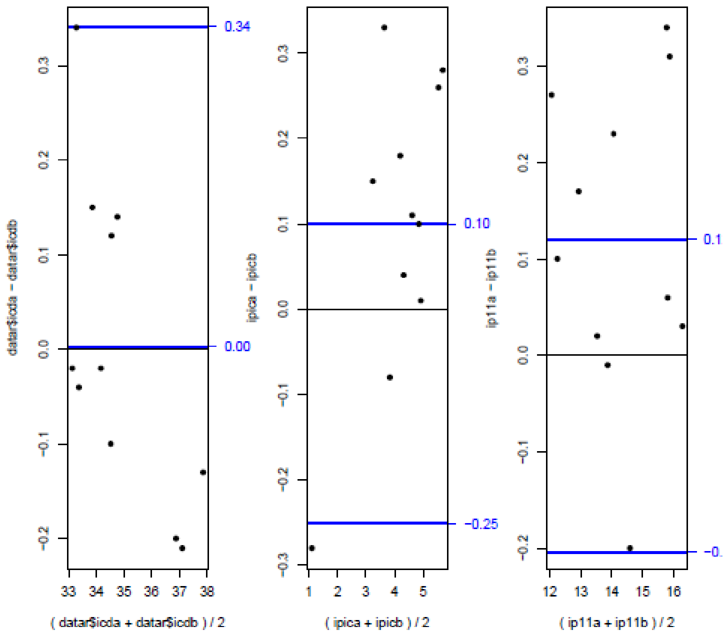


Fig 2.5: Bland Altman plot of difference between the score vs mean of the scores of investigator and supervisor

Table 2.2: Limits of agreement: Inter-rater reliability.

Inter Examiner Variability

	Lower limit	Mean difference	Upper limit
Inter-canine distance	-0.33	0	0.33
Intercanine to papillae	-0.24	0.1	0.44
Papillae to 11	-0.2	0.12	0.44

The ratio of 1:1 between casts and copies was confirmed by measuring the mesio-distal widths of 10 right maxillary first molars on casts as well as corresponding copies. The readings on the casts were compared to those from the copies using Wilcoxon signed ranks test. The measurements from copies were found not to be statistically different from the measurements from the casts (Table 2.3).

Comparison Of Mesio-Distal Widths Of Right Maxillary First Molars Taken From Casts And Corresponding Copies

Table 2.3: Wilcoxon signed ranks test confirming the cast: copy ratio is 1:1

	Mean	Standard deviation
Casts	10.40	0.65
Photo copies	10.47	0.58
Test statistic(Wilcoxon signed ranks test)	–0.306 (p=0.76)	

CHAPTER THREE

3.0 RESULTS

Out of a calculated sample size of 130, 112 participants met the inclusion criteria and were recruited into the study. This translates into a response rate of 86%. Impressions taken as well as casts generated from all the 112 participants were satisfactory in reproduction of surface details and were therefore included in the study. There were 59 (52.6%) male and 53 (47.3%) female participants. The mean age of the participants was 22.39±2.00 years and ranged from 18 to 30 years. The mean age of the male participants was 22.78±2.18 years while that of the female participants was 21.96±1.70 years. The male participants were slightly older than the female participants (t=2.18, DF= 109, p= 0.03), which was statistically significant. (Table 3.1)

Table 3.1: Distribution of participants' age by gender

Gender	n	%	Mean age
Male	59	52.6%)	22.78±2.18
Female	53	47.3%)	21.96±1.70

Out of the 112 casts, 63(56.3%) were tapering in arch form, 26 (23.2%) were ovoid, while 23 (20.5%) were square (table 3.2). The mean age of the participants with the ovoid and tapering arch forms was 22±2.00 years, while those with the square arch form were slightly older with their mean age being 23±2.00 years. However the difference in the age was not statistically significant (p =0.419 and 0.659 respectively). Twenty nine (25.9%) of the participants with the tapering arch form were male while 34 (30.4%) were female. Among the participants with ovoid arches, 15 (13.4%) were male while 11 (9.8%) were female. Fifteen (13.4%) of the participants with square arches were male while 8 (7.1%) were female. Twenty nine (25.9%) of the male participants had tapering arch form while those with both the ovoid and square arch forms were 15 (13.4%). Among the female participants, 34 (30.4%) had tapering arch form, 11 (9.8%) had an ovoid arch form, while 8 (7.1%) had square arch form. There was however no association between the arch form and the gender of the participants (X^2=0.32, df=1, p=0.57). There was an association between arch form and facial profile (X^2=26.59, df=2, $p<0.001$), with 90.4% of participants with convex facial profile having tapering arch forms. There was an association between arch form and body type (X^2=69.88, df=2, $p<0.001$) with 54.43% of participants with mesomorphic body type having the tapering arch forms.

Table 3.2: Distribution of the arch form of the participants by gender

Gender	Arch from	n	%	X^2	P
Male	Tapering	29	25.9%	0.32	0.57
	Ovoid	15	13.4%		
	Square	15	13.3%		
Female	Tapering	34	30.4%		
	Ovoid	11	9.8%		
	Square	8	7.1%		

Seventy nine (70.5%) participants had a mesomorphic body type while 18 (16.1%), had ectomorphic body type and 15 (13.4%) had endomorphic body type. The mean age of the participants with endomorphic and mesomorphic body types was 22±2.00 years, while that of the participants with ectomorphic body type was 22.61±2.75 years. However there was no significant difference between age and the three body types (F=1.4, df=2, p=0.25).

Nine (8.0 %) of the participants with endomorphic body type were male while six (5.4%) were female. Forty three (38.4%) of the participants with mesomorphic body type were male while 36 (32.1%) were female. Seven (6.7%) of the participants with ectomorphic body type were male while 11 (9.8%) were female. Among the male participants, Forty three (38.4%) had mesomorphic body type, 9(8.0 %) had endomorphic body, while 7(6.3%) had the ectomorphic body type. Thirty six (32.1%) of the female participants had the mesomorphic body type, 11(9.8%) had the ectomophic body type, while 6(5.4%) had the endomorphic body type (table 3.3). There was no association between gender and body type (X^2=0.32, df=1, p=0.57).

Table 3.3: Pattern of distribution of body type among the study participants in relation to gender

Gender	Body type	n	%	X^2	p
Male	Mesomorphic	43	38.4%	0.32	0.57
	Endomorphic	9	8.0%		
	Ectomorphic	7	6.3%		
Female	Mesomorphic	36	32.1%		
	Endomorphic	6	5.4%		
	Ectomorphic	11	9.8%		

Out of the 112 participants who were involved in the study, 105 (93.8), had a convex facial profile while 7 (6.25%) had a straight facial profile. No participant had concave facial profile. Among the participants with a convex facial profile, 55 (49.1%) were male while 50 (44.6%) were female. Four (3.8%) of the participants with a straight facial profile were male, while 3 (2.8%) were female. Fifty five (93.2%) of the male participants had a convex facial profile while 4 (6.8%) had straight facial profile. Among the female participants, 50(94.3%) had a convex facial profile while 3(5.7%) had straight facial profile (table 3.4). There was no association between gender and facial profile (X^2=0.32, df=1, p= 0.57). There was an association between body type and facial profile(X^2=85.75, df=1, p<0.001), with 93.67% of participants with mesomorphic body type having convex facial profiles.

Table 3.4: Distribution of the facial profile of the participants

Gender	Facial Profile	n	%	X^2	p
Male	Convex	55	93.3%	0.32	0.57
	Concave	4	6.8%		
	Straight	0	0		
Female	Convex	50	93.4%		
	Concave	3	5.7%		
	Straight	0	0		

The mean age of the participants with convex facial profiles was 22.41±2.02 years while those with straight facial profile had a mean age of 22.14±1.95 years. Although the participants with the convex facial profile were slightly older (22.4 years) as compared to those with a straight face whose mean age was 22.1 years, this difference in age was not statistically significant ,with t=0.344, df=109 , p=0.732.

3.1: Distance from the posterior margin of the incisive papilla to the most labial aspect of the right maxillary central incisor

The mean distance from the posterior margin of the incisive papilla to the most labial aspect of the right maxillary central incisor was 14.93±1.52mm.

The mean distance from the posterior margin of the incisive papilla to the most labial aspect of the right maxillary central incisor among the male participants was 15.00±1.56mm, while among the female participants it was 14.85±1.49mm. The distance from the posterior margin of the

incisive papilla to the most labial aspect of the right maxillary central incisor did not vary with the gender of participants (t=0.52, df=110, p=0.61).
There was a weak negative correlation between age and the distance from the posterior margin of the incisive papilla to the most labial aspect of the right maxillary central incisor (r= –0.178, df= 111, p=0.061).

The mean distance from the posterior limit of the incisive papilla to the most labial aspect of the right maxillary central incisor for participants with tapering, ovoid and square arch forms was 14.68±1.39mm, 15.75±1.31mm and 14.68±1.79mm respectively. The distance from the posterior limit of the incisive papilla to the most labial aspect of the right maxillary central incisor varied with the arch form (F=5.40, df=2, p=0.006). Post-hoc comparisons using the Tukey's HSD test indicated that the mean distance from the posterior margin of the incisive papilla to the most labial aspect of tooth 11 for ovoid arches was significantly different from that of tapering and square arches. Tapering arches did not differ significantly from square arches.

The distance from the posterior limit of the incisive papilla to the most labial aspect of the right maxillary central incisor for participants with endomorphic, mesomorphic and ectomorphic body types were 15.45±1.67mm, 14.83±1.56mm and 14.88±1.14mm respectively. The distance from the posterior limit of the incisive papilla to the most labial aspect of the right maxillary central incisor did not vary with body type (F=1.05, df=2, p=0.35).

The mean distance from the posterior limit of the incisive papilla to the most labial aspect of tooth 11 among participants with convex facial profile was 14.89±1.55mm while that among participants with straight facial profile was 15.45±1.00mm. The distance from the posterior limit of the incisive papilla to the most labial aspect of the right maxillary central incisor did not vary with the facial profile of participant ($t=-0.93$, $df= 111$, $p=0.35$).

There was a weak positive correlation between the inter-canine width and the distance from the posterior limit of the incisive papilla to the most labial aspect of the right maxillary central incisor ($r=0.02$, $p=0.88$). This correlation was not statistically significant.

The distance from the posterior limit of the incisive papilla to the inter-canine line was very strongly positively correlated to the distance from the posterior limit of the incisive papilla to the most labial aspect of the 11 ($r=0.75$, $p< 0.05$) (fig. 3.1).

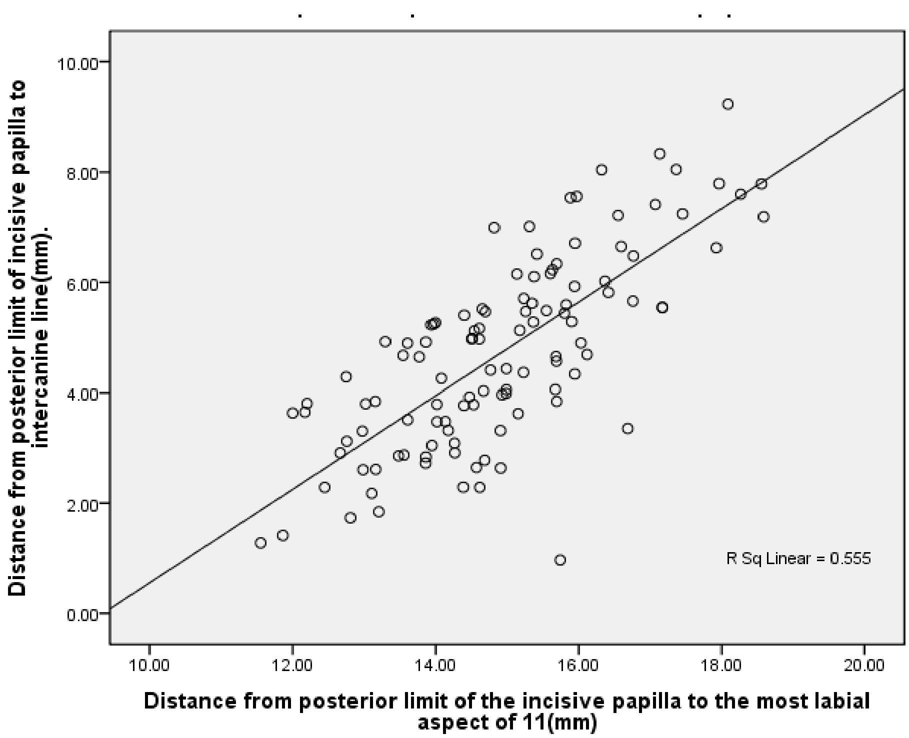


Fig 3.1: Graph of distance from posterior limit of the incisive papilla to inter-canine line versus distance from posterior limit of incisive papilla to most labial aspect of 11.

Inter-canine distance **= b_0 + b**pap11average **+ e**

The model fitted as below:

papintaverage= -7.9282001+0.8481772pap11average

Where:

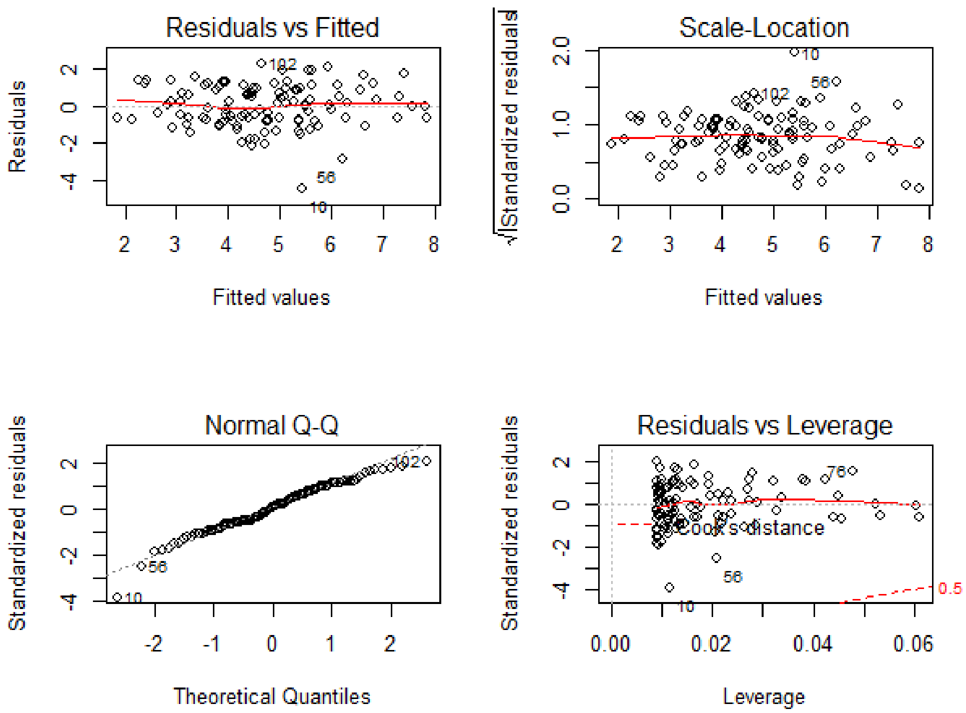
Papintaverage is the distance from the posterior margin of the incisive papilla to the inter-canine line.

Pap11average is the distance from the posterior margin of the incisive papilla to the most labial point of the right maxillary central incisor.

The model was statistically significant on testing the thebo.(F= 137.1

, df = 110, p-value < 0.05)

The diagnostics of the model confirmed that the model assumptions were obeyed as showed below:



3.2: Inter-canine width

The mean inter-canine width was 35.44±1.79mm. There was no association between age and the inter-canine width (Pearson Correlation 0.03, p=0.75) (Fig. 3.2).

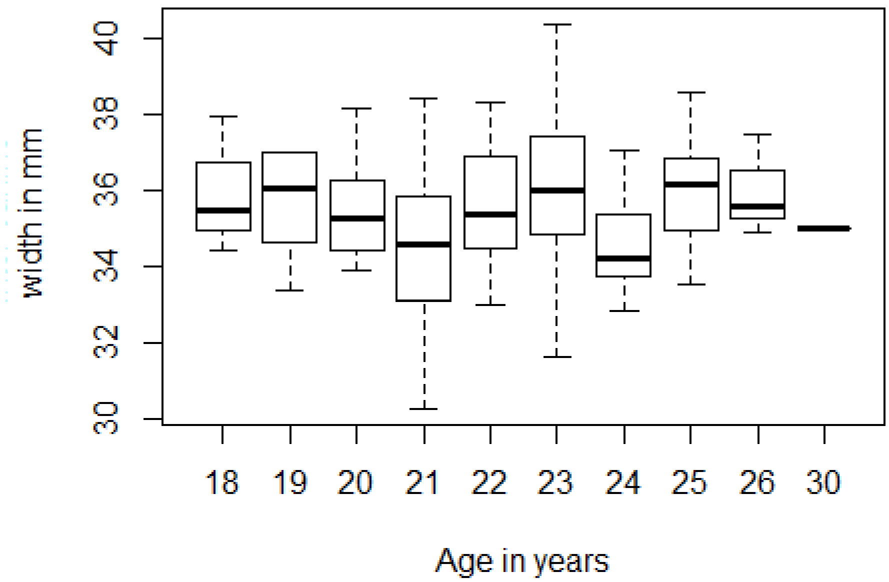


Fig. 3.2 Box plot of the inter-canine width versus age of participants.

The mean inter-canine width for males was 35.86±1.59mm while that for the females was 34.98±1.91mm. The inter-canine width was significantly higher among the males than the females (t=2.68, df= 110, p=0.008).

Participants with tapering arch form had a mean inter-canine width of 35.56±1.73mm. Those with the ovoid arch form had a mean inter-canine width of 34.60±1.99mm, while those with the square arch form had a mean inter-canine width of 36.08±1.41mm. The inter-canine width varied significantly with arch form (F=4.72, df=2, p= 0.01).

Post-hoc comparisons using the Tukey's HSD test indicated that the mean inter-canine width for square arches (M= 36.07, SD= 1.41) was significantly different from that of ovoid arches (M=

34.60, SD=1.99). Tapering arches (M= 35.56, SD= 1.73) did not differ significantly from either ovoid or square arches.

Participants with the endomorphic body type had a mean inter-canine width of 35.03±2.10 mm, those with the mesomorphic body type had a mean inter-canine width of 35.58±1.71mm, while for those with the ectomorphic body type the mean was 35.17±1.93mm. The inter-canine width did not, however, vary with body type (F=0.86, df=2, p=0.43).

Participants with convex facial profile had a mean inter-canine width of 35±2mm while those with the straight facial profile had a mean of 35±1mm. However, there was no significant variation of the inter-canine width with facial profile (t=0.17, df=110, p= 0.86).

3.3 Distance between the inter-canine line and the posterior margin of the incisive papilla

The mean distance from the posterior margin of the incisive papilla to the inter-canine line was 4.73±1.73mm. There was a very weak correlation between age and the distance from the posterior margin of the incisive papilla to the inter-canine line (r= -0.13, p= 0.15) (Fig. 3.3).

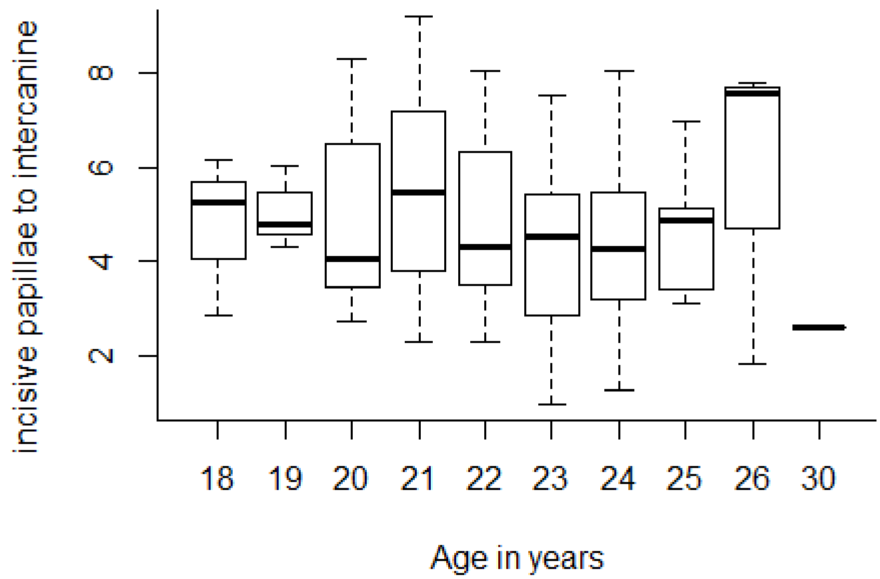


Fig. 3.3: Box plot of distance from the posterior margin of the incisive papilla to the inter-canine line versus the age of participants.

The mean distance from the posterior margin of the incisive papilla to the inter-canine line among the male participants was 4.75±1.93mm, while that for the female participants was 4.71±1.49mm. There was no variation of the relationship between the inter-canine line and the posterior margin of the incisive papilla with gender ($t=0.14$, $df=110$, $p=0.89$).

The mean distances from the posterior margin of the incisive papilla the inter-canine line for participants with tapering, ovoid and square arch forms were 4.37±1.46mm, 5.16±2.00mm and 5.26±1.92mm respectively. The distance between the posterior margin of the incisive papilla to the inter-canine line varied with the arch form ($F=3.40$, $df=2$, $p= 0.04$).

Post-hoc comparisons using the Tukey's HSD test indicated that all the three types of arch forms were unique from each other in how they influenced the relationship between the posterior margin of the incisive papilla and the inter-canine line.

The mean distances from the posterior margin of the incisive papilla the inter-canine line for participants with endomorphic, mesomorphic and ectomorphic body types were 4.51±2.32mm, 4.69±1.61mm and 5.08±1.76mm respectively. The distance between the posterior margin of the incisive papilla to the inter-canine line did not vary with the body type ($F= 0.51$, $df=2$, $p= 0.61$).

Among participants with the convex facial profile, the mean distance from the posterior margin of the incisive papilla to the inter-canine line was 4.71±1.76mm, while that for the participants with the straight facial was 5.00±1.37mm. The distance between the posterior margin of the incisive papilla to the inter-canine line did not vary with the facial profile ($F= 0.17$, $df=1$, $p= 0.68$).

There was a weak negative, non-statistically significant correlation between the inter-canine width and the distance from the inter-canine line to the most posterior limit of the incisive papilla ($r=-0.09$, $p=0.34$) (fig. 3.4).

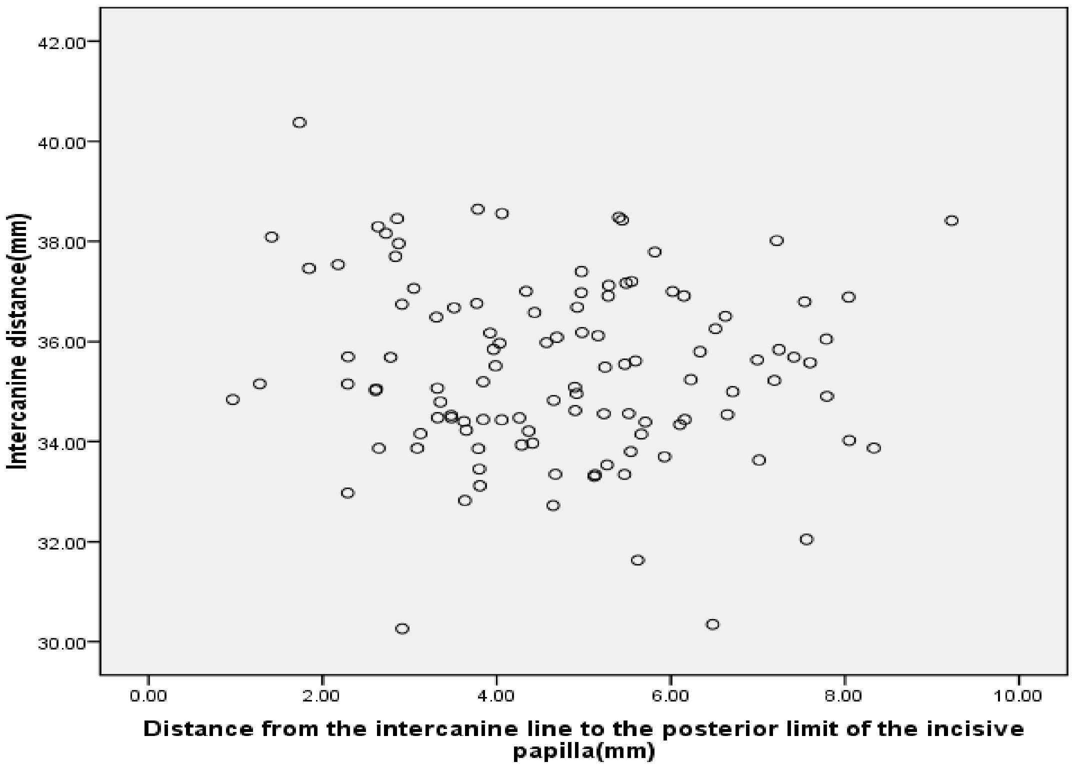


Fig. 3.4: Scatter plot of the inter-canine width versus the distance from the posterior limit of the incisive papilla to the inter-canine line.

CHAPTER FOUR

4.0 DISCUSSION

Most patients requiring complete denture construction in Kenya do not have pre- extraction records to guide placement of prosthetic teeth. In the absence of pre-extraction records, biometric guides are useful in determining positions of denture teeth, thus may contribute to a satisfactory treatment outcome. This study described the relationship between the posterior margin of the incisive papilla and maxillary canines and central incisors, among Kenyans of African descent. The results were compared with those described among Caucasian populations.

In the current study, the mean inter-canine distance was found to be 35.44±1.79mm. Mavroskoufis and Ritchie found the mean inter-canine distance to be 34.3mm among a Caucasian population of dental students[35.] Ehrlich and Gazit established a figure of 34.66(33.04-35.67)mm among Caucasian men and women aged 17-35 years[30]. Keng and Foong found the distance to be 35.74±2.17mm among Chinese aged 18-24 years[23]. Sawiris obtained a mean of 34.48mm among British Caucasians of a mean age of 25.86 years[140]. The findings of this study were, therefore, in agreement with these earlier studies among Mongoloid and Caucasian populations. The inter-canine width among Kenyans of African descent is, therefore, not different to that among Mongoloids and Caucasians. The participants in this study were of the same age bracket as the subjects in these earlier studies. The male participants in this study had a significantly greater inter-canine distance than the females ($t=2.68$, $df= 110$, $p= 0.008$). This finding was similar to that of Keng in an earlier study among a Mongoloid population[131]. Although the male participants in this study were slightly older than the female participants (t=2.18, df=109, p= 0.03), the slight difference in age may not explain the difference. The results of this study may, therefore, mean that males in the study population have wider dental arches than females. There was no variation of the inter-canine distance with body type (F=0.86, df=2, p=0.43) in the present study. This was contradictory to reports that endomorphs commonly have narrow dental arches, ectomorphs have large square dental arches while mesomorphs have normal sized dental arches[142].

The mean distance from the posterior margin of the incisive papilla to the inter-canine line in the present study was 4.73±1.73mm. Watt observed that in dentate mouths, the inter-canine line passes through the middle of the incisive papilla in the coronal plane. After tooth loss, he recommended that the canine tips be positioned in a coronal plane passing through the posterior border of the incisive papilla[122]. This recommendation contradicts the findings of this study (t=28.93, df= 111, p<0.001). However, the findings of the present study are based on dentate subjects and, therefore, the difference may be slightly reduced after compensating for resorption in edentulous persons.

It is difficult to compare the findings of the present study with that of Lassila *et al* who found that the inter-canine line passed very near the posterior margin of the incisive papilla yet failed to report the exact distance[32]. Grove and Christensen measured the orthographic anteroposterior distance between the posterior border of the incisive papilla and a line drawn between the distal contacts of the maxillary canines in Caucasian men and women aged between 12 and 52 years, with a median age of 25 years. The posterior limit of the incisive papilla was 2.695±1.745mm anterior to the line joining the distal points of the canines. No gender, age and arch form differences were noted[36]. The reference in their study was the distal points of the canines, as opposed to tip of the canine used in the present study. As a result, comparison is difficult.

Mavroskoufis and Ritchie reported the inter-canine line to be within 0.6mm from the middle of the incisive papilla among a Caucasian sample[35.] Sawiris found the inter-canine line passing ±1mm from the center of the incisive papilla among British Caucasians[140]. Schiffman found the inter-canine axis to have been ±1mm from the center of the papilla among a Caucasian population[141]. Ehrlich and Gazit investigated the relationship between incisive papilla and maxillary canines among Caucasian men and women aged 17-35 years. In their study, Sixty four percent (64%), 25.6% and 10% of arches were ovoid, square and tapering respectively[30]. The majority of arches were ovoid with the least number being tapering. In the present study, 56.2% of the arches were tapering in arch form, 23.2% were ovoid, while 20.5% were square. The majority of the arches were tapering and a smaller number were ovoid. This differs with the earlier finding by Ehrlich and Gazit[30]. However, the proportion of square arches in this study is similar to the findings of Ehrlich and Gazit[30]. In the study by Ehrlich and Gazit[30], in the ovoid and tapering arches the inter-canine line passed predominantly through the center of the papilla or 1-3 mm posterior to the center of the papilla. In the square arches the inter-canine line passed either through the center of the papilla or 1-2 mm anterior to the center of the papilla. As in this earlier study, the relationship between the incisive papilla and the inter-canine line in the present study varied with the arch form. However, unlike in the earlier study where this relationship was similar for ovoid and tapering but different in square arches, all the three types of arch forms were unique from each other in how they influenced the relationship between the posterior margin of the incisive papilla and the inter-canine line in the present study.

Hickey *et al* suggested that the labial surface of the central incisors should be 8-10 mm from a line that passes through the middle of the incisive papilla from left to right[138]. The studies by Hickey *et al*[138], Mavroskoufis and Ritchie[35], Sawiris[140], Schiffman[141], and Ehrlich and Gazit[30] described the relationship between the middle of the incisive papilla and the inter-canine line. A comparison between these studies and the present study may, therefore, be difficult as the present study used the posterior margin of the papilla to describe this relationship.

The mean distance from the posterior margin of the incisive papilla to the most labial aspect of the maxillary central incisor in the present study was 14.93±1.52mm. Grave and Becker found this distance to be 12-13mm among Caucasian adults[31]. Lassila *et al* studied this relationship among post-menopausal women aged 48-56 years. The racial profile of the subjects were undisclosed, but given the study was carried out in Finland, it likely they were Caucasian. The distance from the posterior border of the incisive papilla to the most labial point of the 11 was 12.08±1.18mm[32]. These figure is significantly different from the findings of the present study ($t=19.82$, $df=111$, $p<0.001$). Ortman and Tsao examined the relationship between the posterior margin of the incisive papilla and the most anterior point of maxillary central incisors among students of unspecified age, race and gender. The mean distance from the most anterior point of the maxillary central incisors to the posterior border of the incisive papilla was 12.454±3.867mm[33]. This finding was also statistically different from the findings of the present study ($t=17.24$, $df=111$, $p<0.001$). Elinger studied the relationship between the distal margin of the incisive papilla and the labial surface of maxillary central incisor among Caucasian men and women aged 21-62 years. He established the distance to have been 12.3±1.2mm (Range=10.0-15.9mm)[34]. The finding differed with the present findings ($t=18.29$, $df=111$, $p<0.001$). Ehrlich and Gazit established a mean distance from the posterior margin of the incisive papilla to the labial surfaces of the central incisors to be 12.31mm (range 12-13.21mm) among Caucasian men and women aged 17-35 years[30]. This finding significantly differs from those of the present study ($t=18.23$, $df=111$, $p<0.001$). Most of these studies were conducted among Caucasian populations. Based on the findings of the current study, it may be appropriate to consider setting the maxillary central incisors slightly more than 12mm from the posterior limit of the papilla. This may be used as a starting point when contouring occlusal rims and while assessing the positions of maxillary central incisors in complete dentures among Kenyans of African descent. However, the ultimate position of the maxillary central incisor must take into account alveolar resorption, aesthetics, incisal relationship of the opposing arch and patient desires. Acceptance of the wax complete denture by the patient at trial stage is also key in acceptance of the final denture.

Despite the wide age variation among the participants of the Caucasian studies (17-62 years), the findings of the studies were not different. This is consistent with finding of the current study that the distance from the posterior margin of the incisive papilla to the most labial point of the maxillary central incisor does not vary with age.

Mavroskoufis and Ritchie found the mean distance from the middle of the incisive papilla to the greatest convexity of the labial surface of the central incisors to be 10.2 mm among a Caucasian population of dental students[35]. Sawiris studied the relationship among British Caucasians and established a mean of 8.56mm. He recommended that the central incisors be set with the labial surfaces 10mm from the posterior edge of the incisive papilla[140]. This recommendation contradicts the findings of the present study. These two studies examined the relationship between the incisive papilla and the maxillary central incisors using the middle of the papilla as the reference point, as opposed to the current study where the reference point was the posterior margin of the papilla. They are not easy to compare with the present study for that reason.

4.1 CONCLUSION

1. The results of the current study indicate that the mean distance from the posterior margin of the incisive papilla to the inter-canine line was 4.73±1.73mm. This finding contradicts the recommendation from Caucasian studies ($t=28.93$, $df= 111$, $p<0.001$).
2. The distance from the posterior margin of the incisive papilla to the most labial aspect of the maxillary central incisor was 14.93±1.52mm among Kenyans of African descent. This is different from findings among Caucasian populations.
3. It may be appropriate to make minor adjustments while positioning maxillary anterior teeth among Kenyans of African descent.

4.2 LIMITATIONS

1. The sample size could not be achieved due to constraints of time.

4.3 RECOMMENDATIONS

1. The placement of maxillary central incisors and canines among Kenyans of African descent during complete denture construction should incorporate the subtle unique features of this population that have been brought out in the present study.
2. Further research may be necessary using the middle of the incisive papilla as reference to establish if similar differences exist between the populations.

REFERENCES

1. Petersen P.E., The World Oral Health Report 2003: continuous improvement of oral health in the 21st century “the approach of the WHO Global Oral Health Programme”. *Community Dentistry and Oral Epidemiology,* 2003; **31**(s1): 3-24.
2. Gerritsen A.E., Allen P.F., Witter D.J *et al*., Tooth loss and oral health-related quality of life: a systematic review and meta-analysis. *Health and Quality of Life Outcome,* 2010; **8**(126): 552.
3. Duvernay E., Srinivasan M., Legrand L.D *et al*., Dental appearance and personality trait judgment of elderly persons. *The International Journal of Prosthodontics*, 2014; **27**(4): 348-354.
4. Petersen P.E., Bourgeois D., Ogawa H. *et al*., The global burden of oral diseases and risks to oral health. *Bulletin of the World Health Organization*, 2005; **83**(9): 661-669.
5. Mughamba E.G., Joury E., Fatusi O., *et al*., Capacity building and financing oral health in the African and Middle east region. *Advances in Dental Research*, 2015; **27**: 32-42.
6. Morita M., Kimura T., Kanegae M., *et al*., Reasons for extraction of permanent teeth in Japan. *Community Dentistry and Oral Epidemiology*, 1994; 22(5PT1): 303-306.
7. Felton D.A., Edentulism and comorbid factors. *Journal of Prosthodontics*, 2009; **18**(2): 88-96.
8. Marcus S.E., Drury T.F., Brown L.J., *et al.,* Tooth retention and tooth loss in the permanent dentition of adults: United States, *1988-1991. Journal of Dental Research,* 1996; **75**: 684-695.

9. Hunt R.J., Beck J.D., Lemke J.H., *et al*., Edentulism and oral health problems among elderly rural Iowans: the Iowa 65+ rural health study. *American Journal of Public Health*, 1985; **75**(10): 1177-1181.

10. Suominen-Taipale A.L., Alanen P., Helenius H., *et al*., Edentulism among Finnish adults of working age, 1978-1997. *Community Dentistry and Oral Epidemiology*, 1999; **27**(5): 353-365.

11. Ngatia E., Gathece L.W., Macigo F.G., *et al*., Nutritional and oral health status of an elderly population in Nairobi. *East African Medical Journal*, 2008; **85**(8): 378-385.

12. Yoshizumi D.T., An evaluation of factors pertinent to the success of complete denture service. *The Journal of Prosthetic Dentistry*, 1964; **14**(5): 866-878.

13. Carlsson G., Otterland A., Wennstro A., Patient factors in appreciation of complete dentures. *The Journal of Prosthetic Dentistry*, 1967; **17**(4): 322-328.

14. Allen P., McMillan A., A longitudinal study of quality of life outcomes in older adults requesting implant prostheses and complete removable dentures. *Clinical Oral Implants Research*, 2003; **14**(2): 173-179.

15. Waliszewski M., Restoring dentate appearance: a literature review for modern complete denture esthetics. *The Journal of Prosthetic Dentistry*, 2005; **93**(4): 386-394.

16. Vallittu P., Vallittu A., Lassila V., Dental aesthetics-a survey of attitudes in different groups of patients. *Journal of Dentistry*, 1996; **24**(5): 335-338.

17. Brewer A., Selection of denture teeth for esthetics and function. *The Journal of Prosthetic Dentistry*, 1970; **23**(4): 368-373.

18. Hirsch B., Levin B., Tiber N., Effects of patient involvement and esthetic preference on denture acceptance. *The Journal of Prosthetic Dentistry*, 1972; **28**(2): 127-132.

19. Lefer L., Pleasure M.A, Rosenthal L., A psychiatric approach to the denture patient. *Journal of Psychosomatic Research*, 1962; **6**(3): 199-207.

20. Nelson A.A., The esthetic triangle in the arrangement of teeth. *The Journal of the National Dental Association*, 1922; **9**: 392-401.

21. Nelson A.A., Selecting mould and hue of teeth for artificial restorations. *Dental Items of Interest*, 1925; **47**: 767-777.

22. Nelson A.A., Optical illusion and the aesthetic triangle in the arrangement of teeth. *Dental Items of Interest*, 1925; **47**: 915-923.

23. Keng S., Foong K., Maxillary arch and central incisor dimensions of an ethnic Chinese population in relation to complete denture prosthodontics. *International Dental Journal*, 1996; **46**(2): 103-107.

24. Jahangiri L., Devlin H., Ting K., *et al*., Current perspectives in residual ridge remodeling and its clinical implications: a review. *The Journal of Prosthetic Dentistry*, 1998; **80**(2): 224-237.

25. Watt D.M., Likeman P., Morphological changes in the denture bearing area following the extraction of maxillary teeth. *British Dental Journal*, 1974; **136**(6): 225.

26. Smith D.E., The reliability of pre-extraction records for complete dentures. *The Journal of Prosthetic Dentistry*, 1971; **25**(6): 592-608.

27. Silverman M.M., Pre-extraction records to avoid premature aging of the denture patient. *The Journal of Prosthetic Dentistry*, 1955; **5**(4): 465-476.

28. Al Wazzan K.A., The relationship between intercanthal dimension and the widths of maxillary anterior teeth. *The Journal of Prosthetic Dentistry*, 2001; **86**(6): 608-612.

29. Harper R.N., The Incisive Papilla The Basis of a Technic to Reproduce the Positions of Key Teeth in Prosthodontia. *Journal of Dental Research*, 1948; **27**(6): 661-668.

30. Ehrlich J., Gazit E., Relationship of the maxillary central incisors and canines to the incisive papilla. *Journal of Oral Rehabilitation*, 1975; **2**(3): 309-312.

31. Grave A., Becker P., Evaluation of the incisive papilla as a guide to anterior tooth position. *The Journal of Prosthetic Dentistry*, 1987; **57**(6): 712-714.

32. Lassila L., Klemetti E., Lassila V., Position of the teeth on the edentulous atrophic maxilla. *Journal of Oral Rehabilitation*, 2001; **28**(3): 267-272.

33. Ortman H.R., Tsao D.H., Relationship of the incisive papilla to the maxillary central incisors. *The Journal of Prosthetic Dentistry*, 1979; **42**(5): 492-496.

34. Ellinger C.W., Radiographic study of oral structures and their relation to anterior tooth position. *The Journal of Prosthetic Dentistry*, 1968; **19**(1): 36-45.

35. Mavroskoufis F., Ritchie G., Nasal width and incisive papilla as guides for the selection and arrangement of maxillary anterior teeth. The *Journal of Prosthetic Dentistry*, 1981; **45**(6): 592-597.

36. Grove H., Christensen L., Relationship of the maxillary canines to the incisive papilla. *The Journal of Prosthetic Dentistry*, 1989; **61**(1): 51-53.

37. Sheiham A., Steele J.G., Marcenes W., *et al*., Prevalence of impacts of dental and oral disorders and their effects on eating among older people; a national survey in Great Britain. *Community Dentistry and Oral Epidemiology*, 2001; **29**(3): 195-203.

38. Muller F., Naharro M., G.E. Carlsson, What are the prevalence and incidence of tooth loss in the adult and elderly population in Europe? *Clinical Oral Implants Research*, 2007; **18**(3): 2-14.

39. Dye B.A., Tan S., Smith V., *et al*., Trends in oral health status: United States, 1988-1994 and 1999-2004. *Vital and Health Statistics. Series 11, Data from the National Health Survey*, 2007; 248: 1-92.

40. Angelillo I.F., Nobile C.G., Pavia M., Survey of reasons for extraction of permanent teeth in Italy. *Community Dentistry and Oral Epidemiology*, 1996; **24**(5): 336-340.

41. Klock K.S., Haugejorden O., Primary reasons for extraction of permanent teeth in Norway: changes from 1968 to 1988. *Community Dentistry and Oral Epidemiology*, 1991; **19**(6): 336-341.

42. McCaul L., Jenkins W., Kay E., Public dental health: The reasons for extraction of permanent teeth in Scotland: a 15-year follow-up study. *British Dental Journal*, 2001; **190**(12): 658-662.

43. Ong G., Yeo J.F, Bhole S., A survey of reasons for extraction of permanent teeth in Singapore. *Community Dentistry and Oral Epidemiology*, 1996; **24**(2): 124-127.

44. Glosssary of Prosthodontic Terms. *Journal of Prosthetic Dentistry*,2005; **94**(1): 68.

45. Ortman H.R., Factors of bone resorption of the residual ridge. *The Journal of Prosthetic Dentistry*, 1962; **12**(3): 429-440.

46. Atwood D.A., Some clinical factors related to rate of resorption of residual ridges. *The Journal of Prosthetic Dentistry*, 2001; **86**(2): 119-125.

47. Tallgren A., The continuing reduction of the residual alveolar ridges in complete denture wearers: a mixed-longitudinal study covering 25 years. *The Journal of Prosthetic Dentistry,* 2003; **89**(5): 427-435.

48. Devlin H., A Clinical Manual for the General Practitioner. 2002, Newyork: Springer.

49. Breine U., Branemark P.I., Reconstruction of alveolar jaw bone. *Scandinavian Journal of Plastic, Reconstructive and Hand Surgery*, 1980; **14**(1): 23-48.

50. Basa S., Varol A., Turker N., Alternative bone expansion technique for immediate placement of implants in the edentulous posterior mandibular ridge: a clinical report. *The International Journal of Oral & Maxillofacial Implants*, 2003; **19**(4): 554-558.

51. Cheng A.C., Tee-Khin N., Siew-Luen C., *et al.*, The management of a severely resorbed edentulous maxilla using a bone graft and a CAD/CAM-guided immediately loaded definitive implant prosthesis: a clinical report. *The Journal of Prosthetic Dentistry*, 2008; **99**(2): 85-90.

52. Alling C.C., Hydroxyapatite augmentation of edentulous ridges. *The Journal of Prosthetic Dentistry*, 1984; **52**(6): 828-831.

53. O'Sullivan M., Hansen N., Cronin R.J., *et al*., The hollow maxillary complete denture: A modified technique. *The Journal of Prosthetic Dentistry*, 2004; **91**(6): 591-594.

54. Feine J., Carlsson G.E., Awad M.A., *et al*., The McGill consensus statement on overdentures. Mandibular two-implant overdentures as first choice standard of care for edentulous patients. *The International Journal of Oral & Maxillofacial Implants*, 2002; **17**(4): 601.

55. Steele J.G., Sanders A.E., Slade G.D., *et al*., How do age and tooth loss affect oral health impacts and quality of life? A study comparing two national samples. *Community Dentistry and Oral Epidemiology*, 2004; **32**(2): 107-114.

56. Sheiham A., Steele J.G., Marcenes W., *et al*., The impact of oral health on stated ability to eat certain foods; findings from the National Diet and Nutrition Survey of Older People in Great Britain. *Gerodontology*, 1999; **16**(1): 11-20.

57. Sheiham A., Steele J.G., Marcenes W., *et al*., The relationship among dental status, nutrient intake, and nutritional status in older people. *Journal of Dental Research*, 2001; **80**(2): 408-413.

58. Abnet C.C., Qiao Y.L., Dawsey S.M., *et al*., Tooth loss is associated with increased risk of total death and death from upper gastrointestinal cancer, heart disease, and stroke in a Chinese population-based cohort. *International Journal of Epidemiology*, 2005; **34**(2): 467-474.

59. Crocombe L., Slade G., Decline of the edentulism epidemic in Australia. *Australian Dental Journal*, 2007; **52**(2): 154-156.

60. Peltzer, K., Hewlett S., Yawson A.E., *et al*., Prevalence of loss of all teeth (edentulism) and associated factors in older adults in China, Ghana, India, Mexico, Russia and South Africa. *International Journal of Environmental Research and Public Health*, 2014; **11**(11): 11308-11324.

61. Zarb G.A. The edentulous predicament. In; *Prosthodontic Treatment for Edentulous Patients*. 12th ed. 2004, p.3. St. Louis: Elsevier-Mosby.

62. Davis D., Fiske J., Scott B., *et al.*, Prosthetics*:* The emotional effects of tooth loss: a preliminary quantitative study. *British Dental Journal*, 2000; **188**(9): 503-506.

63. Blomberg S., Lindquist L., Psychological reactions to edentulousness and treatment with jawbone-anchored bridges. *Acta Psychiatrica Scandinavica*, 1983; **68**(4): 251-262.

64. Sheiham A., Steele J., Does the condition of the mouth and teeth affect the ability to eat certain foods, nutrient and dietary intake and nutritional status amongst older people? *Public Health Nutrition*, 2001; **4**(03): 797-803.

65. Carlsson G., Masticatory efficiency: the effect of age, the loss of teeth and prosthetic rehabilitation. *International Dental Journal*, 1984; **34**(2): 93-97.

66. Chauncey H., Muench M.E., Kapur K.K., *et al*., The effect of the loss of teeth on diet and nutrition. *International Dental Journal*, 1984; **34**(2): 98-104.

67. Appollonio I., Carabellese C., Frattola A.,*et al*., Influence of dental status on dietary intake and survival in community-dwelling elderly subjects. *Age and ageing*, 1997; **26**(6): 445-455.

68. Peyton F.A., History of resins in dentistry. *Dental Clinics of North America*, 1975; **19**(2): 211-222.

69. Peluso M.J., Josell S.D., Levine S.W., *et al*. Digital models: an introduction. in *Seminars in Orthodontics*. 2004: Elsevier.

70. Lang B.R., The use of gold in the construction of mandibular denture base. *Journal of Prosthetic Dentistry*, 1974; 32: 398-404.

71. Winkler S., Denture base resins. *Dental Clinics of North America*, 1984; **28**(2): 287-297.

72. Winkler S., Vernon H.M., Coloring acrylic denture base resins. *The Journal of Prosthetic Dentistry*, 1978; **40**(1): 4-7.

73. Lundquist D.O., An aluminium alloy as a denture-base material. *Journal of Prosthetic Dentistry*, 1963; 13: 102-10.

74. Furnas I.L., *The American textbook of prosthetic dentistry*. 7th ed. Celluloid as a denture base material, ed. A. LP. 1942, Philadelphia: Lea and Febiger

75. Sweeny W.T., Acrylic resins in prosthetic dentistry. *Dental Clinics of North America*, 1958; **11**: 593-602

76. Brydson J.A., *Plastic Materials*. 4th ed. 1982, London: Butterworth Scientific.

77. Woodforde J., *The strange story of false teeth*. 1968, London: Routledge and Kegan Paul.

78. Greener E.H., Harcourt J.K., Lautenschlager E.P., *Materials science in dentistry*. 1972, Baltimore: The Williams and Wilkins Co.

79. Combe E.C., Grant A.A., The selection and properties of materials for dental practice; 7 polymeric denture materials. *British Dental Journal*, 1973; **134**: 289-192.

80. Paffenbarger G., Rupp N., Research techniques used in evaluating dental materials. *The Journal of the American Dental Association*, 1973; **86**(3): 643-651.

81. Combe E.C., *Notes on dental materials*. 6th ed. 1992, Edinburgh Churchill Livingstone.

83. Peyton F.A., Packing and processing denture base resins. *The Journal of the American Dental Association*, 1950; **40**(5): 520-528.

83. Barber R., Preliminary tests of some of the newer denture materials. *The Journal of the American Dental Association*, 1934; **21**: 1969-85.

84. Kimball H.D., Further determinations of the strength of denture materials: Condensites and vulcanites: a progress. *The Journal of the American Dental Association*, 1936; **23**: 1904-13.

85. Gieler C.W., Skinner E., Physical properties of some of the newer denture plastics. *Journal of Dental Research*, 1939; **18**(4): 381-387.

86. Skinner E., Cooper E., Physical properties of denture resins: Part I. Curing shrinkage and water sorption. *The Journal of the American Dental Association*, 1943; **30**(23): 1845-1852.

87. Smith D., The non-metallic denture base-recent developments. *Dental Practitioner and Dental Record*, 1957. **8**: p. 73-80.

88. Woelfel J.B., Paffenbarger G.C., Sweeney W.T., Dimensional changes occurring in dentures during processing. *The Journal of the American Dental Association,* 1960; **61**(4): 413-430.

89. Brauer G.M., Dental applications of polymers: A review. *The Journal of the American Dental Association,* 1966; **72**(5): 1151-1158.

90. Stafford G., Smith D., Further studies in the properties of denture base polymers. *British Dental Journal*, 1968; **125**(12): 529-533.

91. Braden M., Stafford G., Viscoelastic properties of some denture base materials. *Journal of Dental Research*, 1968; **47**(4): 519-523.

92. Brauer G.M., The Present state and Future of Macromolecules for Dental Applications. *Polymer-Plastics Technology and Engineering*, 1977; **9**(1): 87-121.

93. Causton B., *Acrylic and BIS-GMA polymers*. An outline of dental materials and their selection, ed. W.J. O'Brien and G. Ryge. 1978, Philadelphia: W.B Saunders Co.

94. Kydd W.L., Wykhuis W.A., A modified epoxy resin as a denture base material. *The Journal of the American Dental Association*, 1958; **56**(3): 385-388.

95. Smith D., Recent developments and prospects in dental polymers. *The Journal of Prosthetic Dentistry*, 1962; **12**(6): 1066-1078.

96. Brauer G.M., *Polymers in dentistry*. Dental materials review, ed. R.G. Craig. 1977a, Michigan: University of Michigan, School of Dentistry.

97. Chevitarese O., Craig R., Peyton F., Properties of various types of denture-base plastics. *The Journal of Prosthetic Dentistry*, 1962; **12**(4): 711-719.

98. Woelfel J., Newer materials and techniques in prosthetic resin materials. *Dental Clinics of North America*, 1971; **15**(1): 67.

99. Smith D.C., Some aspects of recent developments in denture base materials. *Australian Society Prosthodontic Bulletin*, 1973; **3**: 25-31.

100. Matthews E., Smith D., Nylon as a denture base material. *British Dental Journal*, 1955; **98**(7): 231-7.

101. Watt D., Clinical assessment of nylon as a partial denture base material. *British Dental Journal*, 1955; **98**: 238-244.

102. Anderson J.C., Leaver K.I.D., Alexander I.M., *et al*., Material science. 2nd ed. 1974, London: Thomas Nelson and sons Ltd. 277-94.

103. Johnson J., Jones D., The mechanical properties of PMMA and its copolymers with ethyl methacrylate and butyl methacrylate. *Journal of Materials Science*, 1994; **29**(4): 870-876.

104. Dhir G., Berzins D.W., Dhuru V.B., *et al*., Physical properties of denture base resins potentially resistant to Candida adhesion. *Journal of Prosthodontics*, 2007; **16**(6): 465-472.

105. Stafford G., Huggett R., Mac Gregor A.R., *et al*., The use of nylon as a denture-base material. *Journal of Dentistry*, 1986; **14**(1): 18-22.

106. Hedzelek W., Gajdus P., Comparison of mechanical strength of palatal denture bases made from various plastic materials. *The International Journal of Prosthodontics*, 2005; **19**(2): 193-194.

107. Ring ME., An illustrated history. 1985, New York, Harry N. Abrahams and St. Louis: Mosby, 94-97.

108. Hoffman-Axthelm W., History of Dentistry. 1981. Chicago, IL, Quintessence, 16-286.

109. Fauchard P., Cherugien The Dentist or Dental Trait'e . 1728. Paris , France , Chez Jean Mariette , 284 .

110. Weinberger B.W., An introduction to the history of dentistry, vols I and II. 1948. St. Louis: Mosby.

111. Woodforde J., The strange story of false teeth. 1968. London, Routledge and Kegan Paul.

112. De Chemant M.N.D., A Dissertation on Artificial teeth. 4th ed. 1804. London, T. Bentley.

113. Sproull R.C., A history of porcelain dentistry. *Bulletin of the history of dentistry*, 1978; 26; 1: 3-10.

114. Craddock F.W., A study of artificial posterior teeth. *New Zealand Dental Journal*, 1937; 33: 227-241

115. Anderson D.I.N., Non-metallic denture base materials. In: Applied dental materials.5th ed. London: Blackwell scientific; 1976: 248.

116. Finer Y., Diwan R., Materials used in the management of edentulous patients. In: *Prosthodontic treatment for Edentulous patients* 13th ed. 2013, St Louis: Elsevier.

117. Chamberlain B.B., Razzoog M.E., Robinson E., Quality of care: compared perceptions of patient and prosthodontist. *The Journal of Prosthetic Dentistry*, 1984; **52**(5): 744-746.

118. Vig R.G., The denture look. *The Journal of Prosthetic Dentistry*, 1961; **11**(1): 9-15.

119. Fisher R.D., Esthetics in denture construction. *Dental Clinics North America*, 1957; 1: 254.

120. Vig R.G., Brundo G.C., The kinetics of anterior tooth display. *The Journal of Prosthetic Dentistry*, 1978; **39**(5): 502-504.

121. Misch C.E., Guidelines for maxillary incisal edge position-a pilot study: the key is the canine. *Journal of Prosthodontics*, 2008; **17**(2): 130-134.

122. Watt D., Biometric guides to the design of complete dentures. *Journal (Anglo-Continental Dental Society)*, 1970; 23: 10.

123. Zarb G.A., Bolender C.L., *Boucher's prosthodontic treatment for Edentulous patients* 11th ed. 1997, St Louis: Elsevier.

124. Boucher C.O., The current status of prosthodontics. *The Journal of Prosthetic Dentistry*, 1960; **10**(3): 411-425.

125. Turrell A., Clinical assessment of vertical dimension. *The Journal of Prosthetic Dentistry*, 1972; **28**(3): 238-246.

126. Bissasu M., Pre-extraction records for complete denture fabrication: a literature review. *The Journal of Prosthetic Dentistry*, 2004; **91**(1): 55-58.

127. Angadi G.S., Kakodkar P.V., Bahet S.G., Archiving the Natural Dentition to Serve as Pre-extraction Record: Evaluating Perceptions Among Indian Prosthodontists. *The Journal of Indian Prosthodontic Society*, 2014; **14**(3): 273-280.

128. Lucas, B., Bernardino-Júnior R., Gonçalves L.C., *et al.*, Distance between the medialis angles of the eyes as an anatomical parameter for tooth selection. *Journal of Oral Rehabilitation*, 2009; **36**(11): 840-847.

129. Baker P.S., Morris W.J., Lefebvre C.A., *et al.*, Relationship of denture cast measurements to width of maxillary anterior teeth. *The Journal of Prosthetic Dentistry*, 2011; **105**(1): 44-50.

130. Scandrett F.R., Kerber P.E., Umrigar Z.R., A clinical evaluation of techniques to determine the combined width of the maxillary anterior teeth and the maxillary central incisor. *The Journal of Prosthetic Dentistry*, 1982; **48**(1): 15-22.

131. Keng S., Nasal width dimensions and anterior teeth in prosthodontics. *Annals of the Academy of Medicine, Singapore*, 1986; **15**(3): 311-314.

132. Klemetti E., Lassila L., Lassila V., Biometric design of complete dentures related to residual ridge resorption. *The Journal of Prosthetic Dentistry*, 1996; **75**(3): 281-284.

133. Bidra A.S., Uribe F., Taylor T.D., *et al*., The relationship of facial anatomic landmarks with midlines of the face and mouth. *The Journal of Prosthetic Dentistry*, 2009; **102**(2): 94-103.

134. Sloane R.B., Cook J., A guide to the orientation of the plane of occlusion. *The Journal of Prosthetic Dentistry*, 1953; **3**(1): 53-65.

135. Panjwani, B., Cheryl C., Carlos F.M., *et al*., Palatal rugae: a potential reference to determine key anterior maxilla dimensions and tooth positions. *The International Journal of Prosthodontics*. 2013; **26**(3): 227-229.

136. *The anatomical basis of clinical practice.; Elsevier:* . 39th ed. Gray’s anatomy. 2008, London: Churchill Livingstone.

137. Richard., S.S., *Clinical anatomy by regions*. 8th ed. 2007, Philadelphia: Lippincott Williams.

138. Hickey J.C., Boucher C.O., Woelfel J.B., Responsibility of the dentist in complete dentures. *The Journal of Prosthetic Dentistry*, 1962; **12**(4): 637-653.

139. Martone A., The phenomenon of function in complete denture prosthodontics. Clinical applications of concepts to complete denture prosthodontics. Part VII. Recording phases. *The Journal of Prosthetic Dentistry*, 1963; **13**(4): 4-33.

140. Sawiris M., The role of anthropometric measurements in the design of complete dentures. *Journal of Dentistry*, 1977; **5**(2): 141-148.

141. Schiffman P., Relationship of the maxillary canines to the incisive papilla. *Journal of Prosthetic Dentistry*, 1964; **14**: 469-472.

142. Bhalaji, S.I., *Orthodontics, The Art and Science.* 2nd ed. 1999, New Delhi Arya (Medi) Publishing House.

143. Baelum V., Luan W.M., Chen X., *et al*., Predictors of tooth loss over 10 years in adult and elderly Chinese. *Community Dentistry and Oral Epidemiology*, 1997; **25**(3): 204-210.

144. Hugo F.N., Hilgert J.B., De Sousa M.L.R *et al*., Correlates of partial tooth loss and edentulism in the Brazilian elderly. *Community Dentistry and Oral Epidemiology*, 2007; **35**(3): 224-232.

145. Douglass C.W., Shih A., Ostry L., Will there be a need for complete dentures in the United States in 2020? *The Journal of Prosthetic Dentistry*, 2002; **87**(1): 5-8.

146. Alkhatib M.N., Holt R., Bedi R., Age and perception of dental appearance and tooth colour. *Gerodontology*, 2005; **22**(1): 32-36.

147. Thompson S.C., Thomas C., Rickabaugh C.A., *et al*., Primary and secondary control over age-related changes in physical appearance. *Journal of Personality*, 1998; **66**(4): 583-605.

148. Tin-Oo M.M., Saddki N., Hassan N., Factors influencing patient satisfaction with dental appearance and treatments they desire to improve aesthetics. *BMC oral health,* 2011; **11**(1): 6.

149. Bishara S.E., Treder J.E., Jakobsen J.R., Facial and dental changes in adulthood. *American Journal of Orthodontics and Dentofacial Orthopedics*, 1994; **106**(2): 175-186.

150. Cunha-Cruz J., Pashova H., Packard J.D., *et al*., Tooth wear: prevalence and associated factors in general practice patients. *Community Dentistry and Oral Epidemiology*, 2010; **38**(3): 228-234.

151. Betty R.K., Jonathan A.C.S; *Essential medical statistics*. 2nd ed. 2003. Massachusetts,: Wiley-Blackwell.

152. Proffit W.R., J.L Ackerman, *Orthodontic diagnosis: The Development of a Problem List* 4th ed. Contemporary Orthodontics. 2007, St. Louis: Mosby.

153. Proffit W.R., Ackerman J.L., *Diagnosis and treatment planning in Orthodontics*. 2nd ed. Othordontics, Current principles and Techniques. 1994, St. Louis: Mosby.

154. English JD, D.-Q.T., Salas-Lopez AM. , *Orthodontic records and case evaluation*. Mosby’s Orthodontic Review. 2009, St. Louis: Mosby.

APPENDIX I: DATA COLLECTION SHEET.

Age…………………………Gender…………………………………………………

Facial profile…………………………………Arch form…………………...................

Body type

- ❑ Endomorph
- ❑ Mesomorph
- ❑ Ectomorph.

Intercanine distance

First measurement………Second measurement…………Third measurement……………..

Average…………………………...

Distance from the posterior margin of the incisive papilla the intercanine line

First measurement………Second measurement………Third measurement……………….

Average…………………………...

Distance from posterior margin of incisive papilla to most anterior margin of 11

First measurement………Second measurement……….Third measurement………………...

Average…………………………...

APPENDIX II: CONSENT FORM.

I am a postgraduate student at the dental school of the University of Nairobi. I am conducting a study to investigate certain features in your mouth that can facilitate the replacement of upper front teeth in the event that they are lost. This study will involve taking impressions (measurements) of your upper jaw and teeth; and use of the same to generate a replica of your mouth. This replica will be used for the study. The results of this study will form part of my requirements for the award of the degree.

Any information gathered will be treated in confidence. You may experience mild discomfort and/or nausea during the impression taking. You will have a free dental consultation before the measurement.

Participants may experience any/some of the following during examination or impression taking:

1. Discomfort.
2. Nausea.
3. Swallowing impression material.
4. Allergic reaction to any of the materials.

You are free to choose to participate in the study or not, and to withdraw at any level without any victimization. If you agree please sign below.

DR CYRIL OGADA.

………………………………………………………………………………………………

I, Mr/Mrs/Miss/ms/Dr……………………………………………do hereby voluntarily agree to have my teeth examined and impressions taken of my upper teeth, having received a thorough explanation of the what the process will involve from Dr Ogada.

Sign……………………………………………….Date……………………………………

IDHINI YA KUSIHIRIKI KATIKA UTAFITI.

Mimi ni mwanafunzi wa shahada ya pili katika Chuo Kikuu cha Nairobi. Ninafanya utafiti kudhibitisha iwapo maumbile fulani mdomoni mwako inaweza kusaidia katika harakati ya kukuwekea meno ya mbele unapoyapoteza. Nitapima mdomo yako, kisha nitengeneze mfano wa mdomo yako nitakachotumia katika utafiti yangu. Utafiti huu ni mojawapo ya mahitaji ya shahada ninayosomea chuoni.

Jumbe yote kukuhusu itatumiwa kwa utafiti pekee na kuwekwa kisiri. Unaweza kuhisi kitefutefu, au kumeza chombo kiajali wakati wa kupimwa. Utaangaliwa meno bila malipo kabla ya kupimwa.

Una uhuru wa kuchagua kushiriki katika utafiti huu au kukataa, na hata kujiondoa katika kiwango chochote cha utafiti bila vikwazo vyovyote. Ukikubali tafadhali weka sahihi.

DAKTARI CYRIL OGADA.

……………………………………………………………………………………………

Mimi Bii/Bwana………………………………………………………………………………

Ninakubali kuangaliwa na kupimwa meno baada ya kuelezwa kikamilifu ukweli wote kuhusu shuguli hii na Daktari Cyril Ogada.

Sahihi………………………………………………Tarehe………………………………………

APPEBNDIX III: ETHICAL APPROVAL

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8th May 2013

Dr. Cyril Nyalik Ogada
Dept. of Conservative and Prosthodontics
School of Dental Sciences
University of Nairobi

Dear Dr. Ogada

RESEARCH PROPOSAL: INCISIVE PAPILLA AS A BIOMETRIC GUIDE TO ANTERIOR TOOTH POSITION AMONG KENYANS OF AFRICAN DESCENT (P37/02/2013)

This is to inform you that the KNH/UoN-Ethics & Research Committee (KNH/UoN-ERC) has reviewed and **approved** your above revised proposal. The approval periods are 8th May 2013 to 7th May 2014.

This approval is subject to compliance with the following requirements:

a) Only approved documents (informed consents, study instruments, advertising materials etc) will be used.
b) All changes (amendments, deviations, violations etc) are submitted for review and approval by KNH/UoN ERC before implementation.
c) Death and life threatening problems and severe adverse events (SAEs) or unexpected adverse events whether related or unrelated to the study must be reported to the KNH/UoN ERC within 72 hours of notification.
d) Any changes, anticipated or otherwise that may increase the risks or affect safety or welfare of study participants and others or affect the integrity of the research must be reported to KNH/UoN ERC within 72 hours.
e) Submission of a request for renewal of approval at least 60 days prior to expiry of the approval period. (*Attach a comprehensive progress report to support the renewal*).
f) Clearance for export of biological specimens must be obtained from KNH/UoN-Ethics & Research Committee for each batch of shipment.
g) Submission of an *executive summary* report within 90 days upon completion of the study
This information will form part of the data base that will be consulted in future when processing related research studies so as to minimize chances of study duplication and/or plagiarism.

For more details consult the KNH/UoN ERC website **www.uonbi.ac.ke/activities/KNHUoN**

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Yours sincerely

PROF. M. L. CHINDIA
SECRETARY, KNH/UON-ERC

c.c. Prof. A.N. Guantai, Chairperson, KNH/UoN-ERC
The Deputy Director CS, KNH
The Principal, College of Health Sciences, UoN
The Dean, School of Dental Sciences, UoN
The Chairman, Dept.of Conservative and Prosthodontics, UoN
The HOD, Records, KNH
Supervisors: Dr.Omondi B .I., Dr. Regina Mutave

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