PREVALENCE OF INCISOR RELATIONSHIP AMONG SECONDARY SCHOOL CHILDREN IN KOTA BHARU AND COMPARISON OF CRANIOFACIAL MORPHOLOGY AMONG PATIENTS WITH CLASS I, CLASS II AND CLASS III MALOCCLUSIONS IN HOSPITAL USM

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by

SAMI KHALIFA SALEM ALJAHMI

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LIST OF ABBREVIATIONS

Hospital USM	Hospital Universiti Sains Malaysia.
IBM	International Business Machines.
SPSS	Statistical Package for the Social Sciences.
ANOVA	Analysis of variance.
LCR	lateral cephalometric radiograph.
WHO	World Health Organization.
NOHSS	National Oral Health Survey School.
IOTN	Index of orthodontic treatment need.
Class II div 1	Class II division 1.
Class II div 2	Class II division 2.
USA	United States America.
PAR	Peer Assessment Rating Index.
UCCLP	unilateral complete cleft lip and palate.
BSI	British Standard Institute.
CI	Confidence Interval.
IIUM	International Islamic University Malaysia.
Epi Info	Epidemiology Information Software.
IMU	International Medical University.
PA view	Posterior Anterior view.
LA view	Lateral view.
TMJ	Temporomandibular Joint.
UITM	University Technology Mara.
3D	Three dimensional.

CT	Computer Tomography.
JEPEM	Jawatankuasa Etika Penyelidikan Manusia.
PS	Power and Sample size software.
SD	Standard deviation.
CASSOS	Computer-Assisted Simulation System.
ICC	Intra Class correlation.
MD	Mean Difference.
PPSG	Pusat Pengajian Sains Pergigian.

LIST OF APPENDICES

PREVALEN HUBUNGAN INSISOR DI KALANGAN PELAJAR SEKOLAH MENENGAH DI KOTA BHARU DAN PERBANDINGAN MORFOLOGI KRANOFASIAL DI ANTARA PESAKIT KELAS I, II DAN III DI HOSPITAL USM

ABSTRAK

Prevalens maloklusi yang tinggi telah menjadi satu isu komuniti sedunia. Ia dikira sebagai masalah kesihatan kegigian yang ketiga tertinggi selepas karies gigi dan penyakit gusi. Tujuan utama rawatan ortodontik adalah untuk memperbaiki ketidaksekataan gigi, estetika dentofasial dan fungsi rahang dalam kehidupan pesakit. Kajian ini mempunyai dua objektif: untuk menentukan hubungan prevalens insisor dalam kalangan kanak-kanak sekolah rendah di Kota Bharu dan membandingan morfologi kraniofasial dalam klasifikasi malokulusi yang berbeza di kalangan pesakit berbangsa Melayu di HOSPITAL USM. Objektif pertama merupakan satu kajian keratan rentas melibatkan sejumlah 1300 pelajar (720 wanita, 580 lelaki), berumur 12 hingga 18 tahun dari sembilan sekolah menengah dibawah Kementerian Pendidikan Malaysia. Kandungan sampel mengikut etnik adalah Melayu 67.4% (n=876), Cina 32.1% (n=365) dan India 4.5% (n=59). Kajian ini menggunakan hubungan insisor berdasarkan klasifikasi BSI untuk mengenalpasti prevalens hubungan insisor. Manakala objectif kedua melibatkan sejumlah 120 sefalogram lateral yang di ambil dari 60 orang wanita dan 60 orang lelaki berumur 12-25 tahun berbangsa Melayu. Koleksi radiograf ini dibahagikan kepada kelas maloklusi berdasarkan hubungan gigi molar pertama dari model kajian yang didapati dari bilik rekod klinik Ortodontik, Hospital USM. Perbandingan morfologi kraniofasial antara maloklusi Kelas I, Kelas II dan Kelas III telah dilakukan secara digital menggunakan analisis perisian

sefalometrik lateral Jarabak, Steiner, and Tweed. Semua analisis statistik dilakukan menggunakan perisian IBM iaitu Pakej Statistik untuk Sains Sosial (SPSS) versi 24. Kuasa statistik di letak pada P<0.05. Penilaian One-Way ANOVA telah digunakan. Penemuan ini menunjukkan taburan prevalens hubungan insisor sebagai 791 (60.8%) untuk Kelas I, 277 (21.2%) Kelas II bahagian 1,191 (14.8%) Kelas III dan 41(3.2%) Kelas II bahagian 2. Jika dibandingkan dengan kumpulan lelaki, kumpulan wanita mempunyai pravelen yang lebih tinggi didalam semua maloklusi kecuali Kelas I. Manakala umur kumpulan (12 hingga 14 tahun) mempunyai prevalens yang lebih tinggi dalam Kelas I, Kelas II bahagian 1 dan Kelas III apabila dibandingkan dengan kumpulan umur (15 hingga 18 tahun) yang mempunyai prevalens Kelas II bahagian 2 yang lebih tinggi. Analysis lateral sefalometrik malokulusi Kelas I, Kelas II dan Kelas III dalam kalangan pesakit Melayu dalam kajian ini menunjukkan perbezaan yang signifikan dalam semua ukuran asas kranial, skeletal, pergigian dan tisu lembut. Sudut basal kranial adalah lebih besar pada Kelas II dari Kelas I dan Kelas III. Ketinggian muka anterior dan posterior adalah kurang pada sample Kelas III. Sample Kelas II mempunyai muka yang lebih cembung, manakala sudut muka adalah terbesar pada sample Kelas III. Sudut gigi incisor atas dan bawah adalah tertinggi pada Kelas III dari Kelas I dan II.Ianya boleh dirumuskan bahawa kumpulan kanak kanak berumur 12-18 tahun mempunyai prevalen yang tinngi didalam hubungan insisor Kelas I. Satu per empat dari sample mempunyai Kelas II bahagian 1. Bukti in mungkin boleh digunapakai dalam polisi kesihatan pergigian dalam perancangan strategi pencegahan mereka. Kajian ini menunjukkan perbezaan yang signifikan secara klinikal dalam maloklusi Kelas I, Kelas II dan Kelas III. Penemuan ini juga memaparkan ciri-ciri khusus kraniofasial bangsa Melayu. Implikasi ini telah menunjukkan Kelas I mempunyai maksila prognatik apabila dibandingkan dengan Kelas II yang mempunyai

profil maksila yang lebih prognatik, manakala maloklusi Kelas III mempunyai profil maksila yang lebih retrognatik dan mandible yang lebih prognatik.

PREVALENCE OF INCISOR RELATIONSHIP AMONG SECONDARY SCHOOL CHILDREN IN KOTA BHARU AND COMPARISON OF CRANIOFACIAL MORPHOLOGY AMONG PATIENTS WITH CLASS I, CLASS II AND CLASS III MALOCCLUSION IN HOSPITAL USM

ABSTRACT

The high prevalence of malocclusion has created a community health issue worldwide; which is considered as the third highest oral health threat after tooth decay and periodontal disease. The ultimate purpose of orthodontic treatment has always been to improve the teeth irregularity, dentofacial aesthetics, and jaw function in order to enhance the life of a patient. This current study has two main goals: to determine the prevalence of incisor relationship among school children in Kota Bharu and to compare the craniofacial morphology among Class I, Class II and Class III malocclusions of Malay patients in Hospital USM. This is a cross-sectional study of 1300 students 720 females, 580 males, from nine government schools in the age groups range from 12 to18 years old was included. The ethnic proportional of the sample was Malay 67.4% (n=876), Chinese 28.1% (n=365) and Indian 4.5 % (n=59). The incisor relationship based on BSI classification was used to establish the prevalence. A total of 120 lateral cephalograms from 60 females and 60 male's Malay patients with age group 12 to 25 years old were selected based on the molar relationship of the study model from the archive of Orthodontic Clinic, Hospital USM. The lateral cephalometric radiographs were traced digitally and analyzed based on Jarabak, Steiner, and Tweed. The statistical analyses were done using IBM software Statistical Package for the Social Sciences (SPSS) version 24. The statistical power was set at

P<0.05. One-Way ANOVA test was performed. The finding has shown the prevalence of incisor relationship was 791 (60.8%), 277 (21.2%), 191 (14.8%) and 41 (3.2%) for Class I, Class II div 1, Class III and Class II div 2 respectively. The female has higher prevalence in all malocclusions except Class I when compared to male. Age group 12 to 14 years old had higher prevalence of in Class I, Class II div 1, and Class III when compared to the age group 15 to 18 years old which had a high prevalence of Class II div 2. The lateral cephalometric analysis of Class I, Class II and Class III malocclusions had shown a significant difference in all cranial base, skeletal, dental and soft tissue measurements. Class II has more value of cranial base angle than Class I and Class III. The anterior facial high and posterior facial high was displayed as the lowest value in Class III. Class II sample has shown more convex profile whereas Class III has bigger facial angle. The relationship between the upper and lower incisor teeth was presented in Class III as the highest value than Class I and Class II. It is concluded that the Class I incisor relationship is the most prevalent in the school children aged 12 to 18 in Kota Bharu. A quarter of the sample presented with Class II div 1. This evidence is applicable in oral health policy in their preventive strategies planning. This study showed clinically significant differences in Class I, Class II and Class III malocclusion. There is a distinct craniofacial feature of Malay patients. Implications of these have shown Class I presented with less prognathic maxilla when compare to Class II malocclusion. Class II has shown more forward of the maxilla and prognathic profile. Retruded maxilla with forward mandible indicated to retrognathic profile and vertical growth pattern displayed in Class III malocclusion.

CHAPTER ONE

INTRODUCTION

1.1 Background of the study

Occlusion is well-defined as a method when the upper and lower teeth in intercuspation between each other in all mandibular positions and movements. It is a product of neuromuscular management of the sections of the mastication procedures such as teeth, maxilla and mandibular, periodontal structures, temporomandibular joints and their related muscles and ligaments (Hassan and Rahimah, 2007).

In 1899, Dr. Edward Angle termed malocclusion as "irregularities of teeth (Angle, 1899). Which can also be defined as the state of any deviation from the normal or ideal occlusion (Daskalogiannakis, 2000). From the perspective of an ideal occlusion, the morphological change can be deemed unacceptable functionally and aesthetically (Houston WJB, 1992). The incisors teeth when becoming exposure during speech and smiling or when the lips are at rest is a critical aspect in facial aesthetics, as it affects the perception of the individual face (CALP, 2006). The World Health Organization in 1977 had included malocclusion under the description of handicapped dentofacial abnormality (WOH, 1977).

Malocclusion aetiology can be due to inherited factors with some stimulus during the formation and growth of orofacial structures as well as environmental factors such as oral habits, diet, trauma, and social features (Dimberg *et al.*, 2015; Heimer *et al.*, 2008).

Malocclusion's high prevalence has become a public health issue worldwide; which is reflected as the third-highest oral health crisis after tooth decay and periodontal diseases (Marques *et al.*, 2009; Tak *et al.*, 2013). Malocclusion can lead to psychosocial and oral function problems which lead to damaged dentofacial aesthetics (Bellot-Arcis *et al.*, 2013; Masood *et al.*, 2013).

Other oral health problems resulted from malocclusion are temporomandibular joint dysfunction, disability in jaw movement and problems with mastication which can lead to mental ill-health, physical, and social problems (Proffit *et al.*, 1998; Thilander *et al.*, 2001). Moreover, it can further contribute to the grander vulnerability of tooth decay, periodontal disease and anterior teeth injury resulting from protruding maxillary incisors (Burden, 1995; Jones and Nunn, 1995).

The prevalence of malocclusion among various ethnic groups has been reported. The outcomes revealed a wide range of prevalence malocclusion (Mtaya *et al.*, 2009). This wide prevalence of malocclusion was distributed in children and adolescents group among Indians, Caucasian, Middle-eastern, and African as 39%, 74%, 86% and 98% respectively (Behbehani *et al.*, 2005; Dhar *et al.*, 2007; Rwakatema and Nganga, 2006; Thilander and Myrberg, 1973). In the Malaysian National School Oral Health Survey (NSOHS 2007) conducted on 16-year olds in 2007, the prevalence of malocclusions was reported to be 35.5% (Health, 2009). The differences in the age groups of the populations studied, ethnicity and different sample sizes could be the reason for the variations. Furthermore, the differences could be because of modifications in the registration methods (Abu Alhaija *et al.*, 2005).

The ultimate purpose of orthodontic treatment is to improve teeth irregularity, dentofacial aesthetics, and jaw function in order to enhance the patient's life. On the other hand, appropriate treatment is vital for patient's comfort because the presence of facial and dental distortions can increase an unnecessary disability that may interfere both the mental and physical health of patients (Graber *et al.*, 2016).

Additionally, morphological characteristics of different ethnic clusters are not randomly spread but performed in geographic groups. Studies on craniofacial differences and relations have long been used to distinguish several racial groups in physical anthropology (Argyropoulos and Sassouni, 1989).

Craniofacial morphology was influenced by both genetic and environmental factors whereby the genetic constituent has a significant influence more on the anterior-posterior rather than the vertical facial form. The vertical facial form is affected by mainly three environmental factors such as soft tissue stretching, the structure-function of the muscle of mastication, and certain habits such as mouth breathing (Mitchell, 2013)

The craniofacial morphology is being associated with the different types of skeletal and dental anomalies (Baldwin, 1980). Cranial base angle and length was reduced in Class III compared Class I and Class II div 1, malocclusion (Hopkin *et al.*, 1968). Another study has shown an increased cranial base angle in Class II malocclusion (Anderson and Popovich, 1983).

Craniofacial morphology analysis is an important factor in orthodontic assessment and clinical treatment, which provides information that enables the Classification of the skeletal as well as dental anomalies (Wahab *et al.*, 2013). Cephalometric analysis was widely used to detect malocclusions from significant differences between dentofacial

proportion as intermaxillary relationships influenced the teeth position. It is an important diagnostic technique in determining facial disharmonies during an influence on facial growth and treatment (Kuramae *et al.*, 2007).

A previous study in Class I malocclusion among Saudi and Japanese females have shown the vertical dimension for both a steep mandibular plane angle. Moreover, in lower face height has revealed a significantly higher together with enhanced distances of the upper molars to the palatal plane. Furthermore, for the soft tissue feature, the Japanese had a significantly less prominent nose and protruded lip positions when compared with Saudis (Abbassy and Abushal, 2015).

Craniofacial morphology of Class II div 1, malocclusion was revealed to be associated with several types of craniofacial morphologies (Ballard and Wayman, 1965; Graber *et al.*, 2016). It could be due to anomalies in skeletal or dental sections in maxilla and mandible or both (Ellis III *et al.*, 1985). A study was done among Naples population have shown Class II div 1, more prognathic in the maxilla with retruted upper incisors and retrognathic mandible with proclined lower incisors (Bajracharya *et al.*, 2012).

The orthognathic maxilla is usually displayed in Class II div 2 malocclusions, the features of Latin population was relatively short and retrognathic mandible, hypodivergent facial pattern, relatively prominent chin, deep overbite and retruted maxillary central incisors (Kuramae *et al.*, 2007).

In Class III malocclusion among Japanese female has shown a difference in the craniofacial feature when compared with Caucasian, which was revealed a significantly reduced in anterior cranial base, more obtuse gonial angle, anterior lower face highest was increased and more proclined in upper incisor (Ishii *et al.*, 2002).

1.2 Problem statement

In order to provide efficient orthodontic services, information on the prevalence of malocclusion and orthodontic treatment need are important as these would be useful to help the orthodontist in planning and improving oral health care. None of the studies in Kota Bharu have determined the detailed prevalence of the incisor relationship which makes up the insufficient epidemiological data on the prevalence among this region.

There is lack of any comparative studies about detailed differences of craniofacial morphology in different classes of malocclusion of Malay patient in Hospital USM for emphasizing the significance of its morphology and the role in establishing the malocclusion, which might be made this study a subject of interest particularly to compare the skeletal, dental and soft tissues variances among patients in Hospital USM.

1.3 Justification of the study

The knowledge of the prevalence of incisor relationship among adolescents of school children, Kota Bharu, Kelantan, Malaysia will be useful for orthodontic treatment planning as the improvement in the early detection and treatment of malocclusions was emphasized on preventive procedures which can be achieved by collecting more information on patients in the adolescent age group. The preventive measures can minimize the potential irregularities in the development of complex dentofacial as treatment can still be offered during the active growth phase.

This study also intends to examine the characteristic of craniofacial morphology in different classes of malocclusion among Malay patients of Hospital USM using cephalometric radiographs which were selected accordingly to the molar relationship in order to evaluate the difference of Class I, Class II and Class III malocclusions. This knowledge will be helpful for accurate clinical diagnosis and efficient decision on treatment planning of orthodontic and orthopaedic procedures.

1.4 Objective of the study and Hypothesis

1.4.1 General Objective

The purpose of this study was to determine the prevalence of incisor relationships among 12 to 18-year-old school children and compare the craniofacial morphology of 12 to 25-year-old patients attending for treatment in Hospital USM.

1.4.2 Specific Objective

The Specific objective of this study was:

- To determine the prevalence of Class I, Class II div 1, Class II div 2 and Class III incisor relationship among 12 to 18-year-old, school children in Kota Bharu, Kelantan, Malaysia.
- To compare the craniofacial morphology of Class I, Class II and Class III malocclusions among 12 to 25-year-old, Malay patients in Hospital USM, Malaysia using lateral cephalometric analysis.

1.5 Research Question

a) What is the prevalence of Class I, Class II div 1, Class II div 2 and Class III incisor relationship among 12 to 18-year-old school children in Kota Bharu, Kelantan, Malaysia?

b) Is there any significant difference compared to craniofacial morphology of Class I, Class II and Class III malocclusions among 12 to 25-year-old, patients in Hospital USM?

1.6 Research Hypothesis

a) The prevalence of Class I, Class II div 1, Class II div 2 and Class III incisor relationship among 12 to 18-year-old school children in Kota Bharu, Kelantan, Malaysia is high.

b) There is a significant difference in craniofacial morphology of Class I, Class II and Class III malocclusions among 12 to 25-year-old, patients in Hospital USM.

CHAPTER TWO

LITERATURE REVIEW

2.1 Occlusion

An individual's occlusal condition is commonly defined by two major features: inter-arch relationship, the pattern of occlusal relations between the upper and lower teeth and intra-arch relationship, the relationship of the teeth within each arch to an efficiently curving line of occlusion (Proffit, 1986). A physiologic occlusion varies from a pathological occlusion in which the components function effectively and without pain, and persist in a good condition of health (Hassan and Rahimah, 2007).

2.2 Ideal occlusion and normal occlusion

An ideal occlusion is a hypothetical theory based on the anatomy of the teeth and rarely noticed in nature. The theory is utilized to a condition when the skeletal bases of maxilla and mandible are of the appropriate size relative to each other and the teeth should be in a proper relationship in all three planes of space at rest (McDonald and Ireland, 1998).

Normal occlusion according to Houston (1992) was an occlusion within the deviation of the ideal occlusion but still accepted aesthetically or functionally. It was not possible to identify accurately the limits of normal occlusion as long as there was no indication that an anomaly could be harmful to the patient (Houston WJB, 1992).

2.3 Malocclusion

Malocclusion can be defined as deviation from normal occlusion which is considered as one of the most prevalent oral health problems (Bhardwaj *et al.*, 2011; Mtaya *et al.*, 2009). It is relatively a common oral health issue that may lead to masticatory, aesthetics, psychological, and social problems (Das and Venkatsubramanian, 2008). Malocclusion can be further described as the relationship of the dental arch in relation to the normal occlusion which presents in any of the three planes of spaces; vertical, transverse, and anteroposterior. It can also be described as misalignment of individual teeth in each arch whereby the teeth may take a position away from the smooth curve of the arch; where they can be displaced, tipped, rotated, supraocclusion, infraocclusion or transposed (Proffit, 1986).

Malocclusion has an important negative influence on both children and adults (Graber *et al.*, 2016; Shaw *et al.*, 1980) and can cause speech problem, chewing difficulties and psychosocial suffering (Grimm, 2004; Petti and Tarsitani, 1996), periodontal complications and temporomandibular joint disease (Geiger, 2001), bruxism (Ghafournia and Tehrani, 2012), headache (Komazaki *et al.*, 2014), On the bright side, early development of malocclusion can be predicted which may assist orthodontist in developing management strategies taking full advantage of the active growth phase (Proffit *et al.*, 2000; Vig and Fields, 2000).

2.3.1 Classification of malocclusion

Several types of classification of malocclusion have been generated for numerous purposes. The requirements for clinical categorization can differ from those of epidemiology (Houston WJB, 1992). Some types of classification of malocclusion have been described based on:

a) Epidemiological data collection

Determination of malocclusion was established for epidemiological data collection and to regulate the technique of assessing and illustrating all occlusal trait within a population (Baume and Maréchaux, 1974; Bezroukov *et al.*, 1979; Björk *et al.*, 1964)

b) Priority treatment need - dental health

Handicapping Labiolingual Deviation Index (Draker, 1960), Occlusion Index (Summers, 1971) and Index of Orthodontic Treatment Need (Brook and Shaw, 1989) which are elements of dental health components were established to evaluate the need for treatment based on dental health in a population so that priority can be allocated to chosen cases when resources were restricted.

c) Priority treatment need-aesthetic

Index of Orthodontic Treatment Need (Brook and Shaw, 1989) taken into account aesthetic component which was acquired in response to social science reviews that highlighted the significance of aesthetic damage on the patient's psychological aspect.

d) Occlusal classification

There are two methods of measuring the occlusal classification; Angle's classification according to the first permanent molar relationship (Angle, 1899) and the British Standard Institution based on incisor relationship (British Standards, 1983), which

then provide an explanation of malocclusion with permitted communication between physicians.

e) PAR Index

Peer Assessment Rating Index (PAR) was utilized to contrast pre and post-orthodontic treatment reports by using (PAR) Index component and registered the superiority of the consequences of different treatment strategies (Richmond *et al.*, 1992). This Index component was used for scoring the anomalies in upper and lower anterior teeth such as crowding, spacing and impacted teeth, buccal occlusion by utilizing all three planes of space which recorded from the canine to the terminal molar for the anterior-posterior and vertical dimension but the canine is excluded from the transverse dimension. Overjet is measured from the most prominent incisor; overbite is measured in relation to the lower incisors with the greatest coverage by an upper incisor. For an open bite recorded by the greatest space between the incisal edges. The centerline divergence is measured in relation to the lower central incisors (Green, 2016).

f) Dental arch relationships

One of the classifications is GOLSON Yardstick (Great Ormond Streat London and Oslo) procedure which was established for classifying dental arch relationships in children with unilateral complete cleft lip and palate (UCCLP) observed in the mixed dentition and permanent dentition (Mars *et al.*, 1992). This can also be used to plan surgery and its outcome as early as 5 years of age (Atack *et al.*, 1997).

2.3.2 Aetiology of malocclusion

The aetiology of different types of malocclusions are complicated and varied which includes both environmental factors and genetic factors. Environmental factors such as sucking habits have been accompanied with anterior open bite and posterior crossbite (Larsson, 1986). Most often, a combination of both genetic and environmental factors influenced the developing dentition and determined whether a person will end up with malocclusion (Vázquez-Nava *et al.*, 2006; Zicari *et al.*, 2009).

The genetic factors such as genetic syndromes and congenital development may cause a defect of embryologic growth, admixture, and breeding which may produce a reduction in tooth size and jaws which in turn may create tooth size and jaw discrepancies (Proffit, 1986). Furthermore, the mouth breathing was_showed the correlation with malocclusion which found that alterations on craniomaxillofacial, generally caused by abnormal mandible displacement and following dysmorphism of the oral structures and altered posture. The causes of mouth breathing are categorized as either inherited or acquired. The previous consist of; choanal atresia, nostril atresia, and nasal septum deviations. The last included; rhinopharyngitis, allergic rhinitis, nasal polyposis, chronic sinusitis, chronic adenotonsillitis, chronic hypertrophic rhinitis, adenotonsillar hypertrophy, malignant and benign tumor's (Zicari *et al.*, 2009).

2.3.3 The measurement of the occlusal trait

In reporting and determining malocclusion, it is important to determine the prevalence and severity amongst the various population, because it was documented that many of the previous results of epidemiological research were different due to the dissimilar assessment of the features recorded. Occlusal traits can be evaluated directly from the

mouth or indirectly on a study cast or dry skull (Lavelle, 1976). The methods used for recording the occlusal traits can be divided into quantitative and qualitative measurements (Tang and Wei, 1993).

Quantitative methods are beneficial in describing the deviation of an occlusal trait such as the severity of malocclusion and treatment prioritization (Han and Davidson, 2001). Qualitative methods are convenient in expressing the occlusal traits for classifying the various types of dental malocclusion. Two well-known qualitative methods are Angle's and British Standard Institute classifications.

❖ Angle's classification of malocclusion

This classification was used to define and classify the occlusion based on molar relationship throughout the upper first permanent molar related to the lower first permanent molar which was measured the occlusion by the mesiobuccal cusp of the upper first molar in relation to the mesiobuccal groove of the lower first permanent molar. Angle categorized the malocclusion into 3 classes (Angle, 1899) as following as and shown in (Figure 2.1):

- Class I molar relationship is when the mesiobuccal cusp of upper first permanent molar occludes the mesiobuccal groove of the lower first permanent molar.

- Class II molar relationship is when the mesiobuccal cusp of upper first permanent molar occludes mesially to the mesiobuccal groove of the lower first permanent molar. Class II has subdivided into two divisions based on the inclination of upper incisors i.e. Class II div 1, is when the upper central incisors are proclined and Class II div 2 is when the upper central incisors are retroclined.

- Class III molar relationship is when the mesiobuccal cusp of upper first permanent molar occludes distally to the mesiobuccal groove of the lower first permanent molar.

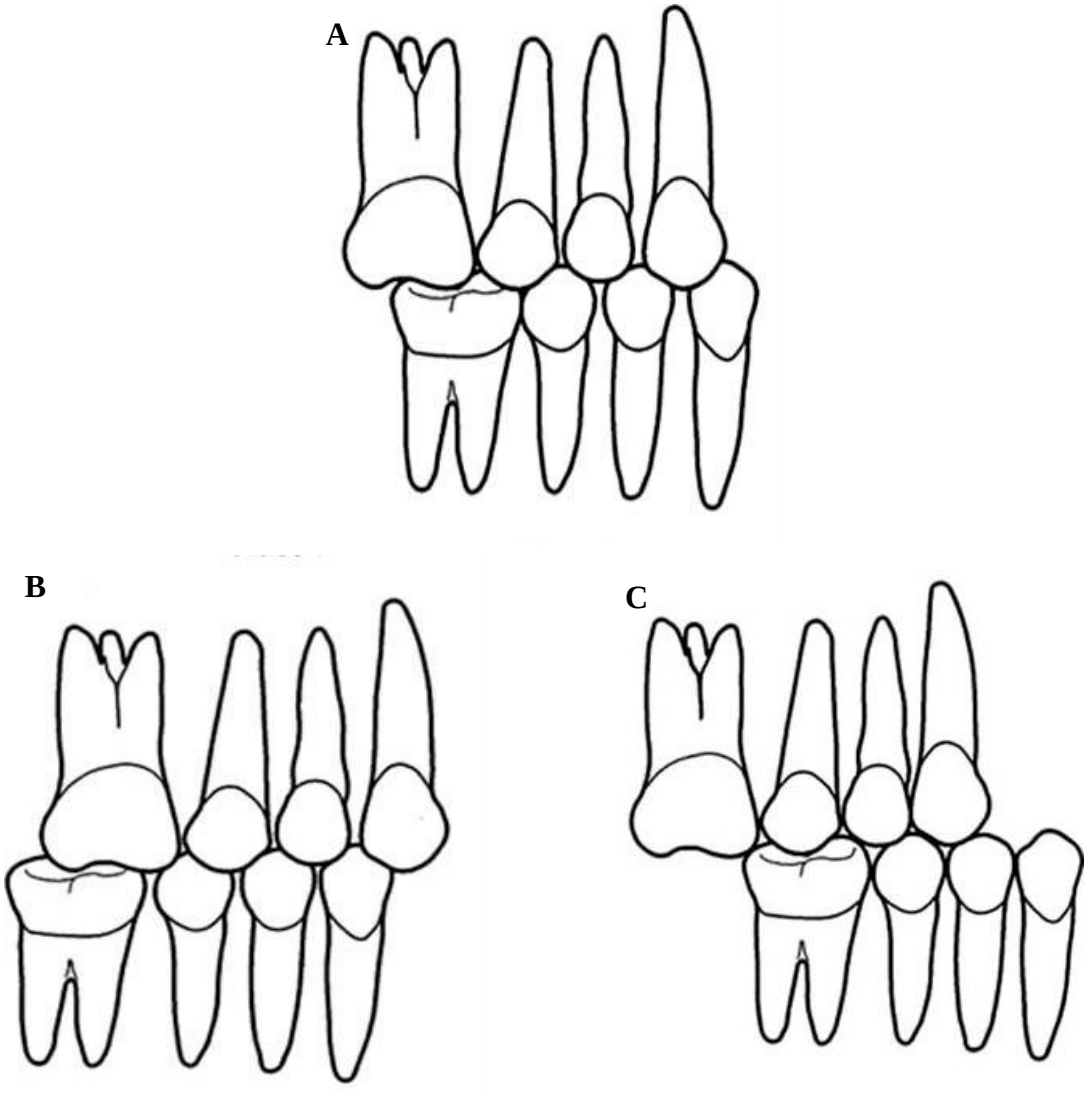


Figure 2.1 Angel's molar classification (1899).

A) Class I. **B)** Class II **C)** Class III.

❖ British Standard Institute (BSI) classification

The (BSI) classification was defined and classified based on incisor relationship (Ballard and Wayman, 1965), which was classified into 4 classes and shown in (Figure 2.2) such as:

- Class I incisor relationship is when the incisor edge of lower central incisors occludes with or lie immediately below the cingulum plateau of upper central incisors
- Class II div 1, incisor relationship is when lower central incisor edges occlude posterior to the cingulum plateau of the upper central incisors with increased overjet and proclined upper central incisors.
- Class II div 2, incisor relationship is when lower central incisor edges occlude posterior to the cingulum plateau of the upper central incisors with minimal overjet and retroclined upper central incisors.
- Class III incisor relationship is when the incisor edge of lower central incisors lies anterior to the cingulum plateau of upper central incisors with reversed overjet or edge to edge contacts of the upper and lower incisors.

These methods are used to describe the occlusion feature in different types of dental malocclusions which could be easily and quickly recorded as well as have been widely used in many prevalence's of malocclusion reports (Soh *et al.*, 2005).

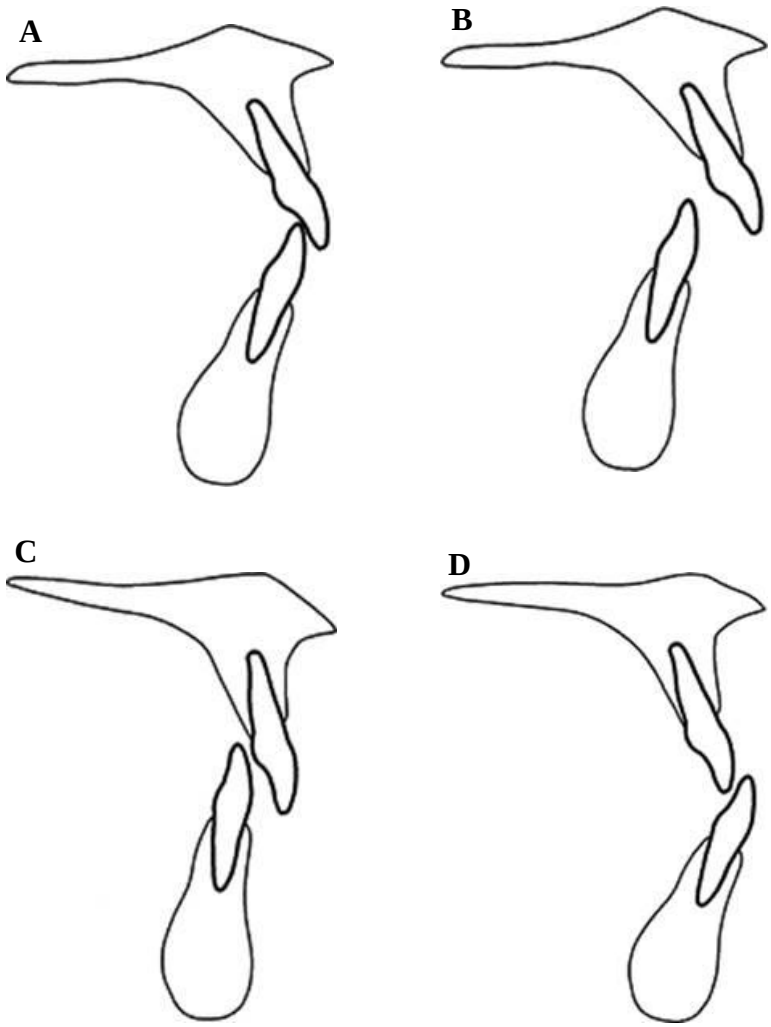


Figure 2.2 Incisor relationships BSI (1965).

A) Class I. **B**) Class II div 1. **C**) Class II div 2. **D**) Class III.

2.4 Prevalence of malocclusion

The planning of orthodontic treatment within the community's health organization demands the information prevalence and distribution of malocclusion (Foster and Menezes, 1976) due to it being one of the most common dental issues after dental caries and periodontal problems (Dhar *et al.*, 2007).

Analysis of prevalence of occlusal characters in isolated human populations can provide valuable data regarding the malocclusions and other complex traits unique to that population which can be used to plan treatment according to the specific findings of the population (Rudan *et al.*, 1999).

Epidemiological studies accomplished in different populations reported on the widespread prevalence of malocclusion among various ethnic groups (Bhardwaj *et al.*, 2011; Sheikh *et al.*, 2014).

2.4.1 Prevalence of malocclusion among Asian population

In Asian populations were found to have higher prevalence for Class III malocclusion which ranged from 12.6% to 34.1% (Ismail *et al.*, 2017; Soh *et al.*, 2005), but also noticed that prevalence of Class I and Class II malocclusion was lower compared to African and North American population (Mtaya *et al.*, 2009; Proffit *et al.*, 1998). These information help orthodontist to recognize the existing problem of a specific ethnic group in a geographic location and assist them in the planning of responsive and preventive procedures (Sandeep and Sonia, 2012).

A retrospective study was conducted by Ismail (2017), in Kuantan, Malaysia organized by the Orthodontic Clinic of Kulliyyah of Dentistry of International Islamic University Malaysia (IIUM) involving 560 patients treated in the clinic from 2009 until 2014.

Patients' data were collected from the patient's folder and subjects were selected based on inclusion criteria which were the major ethnic groups i.e. the Malays, Chinese, and Indians and in the age group of 7 to 18 years. The examination was performed on study models and the BSI classification was used to evaluate the occlusal traits. The distribution of malocclusion was found as 34.1%, 32.7 %, 25.7%, and 7.5% for Class III, Class II div 1, Class I and Class II div 2 respectively (Ismail *et al.*, 2017).

Another Malaysian study in (2014) was performed by Sheikh, at International Medical University, Kuala Lumpur, Malaysia to estimate the prevalence of malocclusion and self-esteem among young adults in Malaysia. A total of 142 subjects in the age group of 18 to 25 years was recruited excluding subjects with undergoing orthodontic treatment, missing or fractured incisors, and restorations on lower and upper central incisors. Subjects distribution were Chinese (73.9%), followed by Indians (16.9%), Malays (5.6%), and others (3.5%). Malocclusion was recorded using Angle classification and was found as 48.6%, 16.2%, and 26.8% for Class I, Class II, and Class III respectively and normal occlusion was noticed as 8.5% (Sheikh *et al.*, 2014).

The former a study on malocclusions attained, at the National University of Singapore among three ethnic groups of 339 males (Chinese, Malay, and Indian) in the age group of 17 to 22 years old was achieved by Soh (2005). This study was performed on voluntary basis participation which excluded subjects with previous orthodontic treatment and craniofacial anomalies such as cleft lip and palate and carrying out both medical and dental examinations. The BSI classification based on the incisor relationship was used in describing the occlusal traits. Class I malocclusion was shown the most common, followed by Class II div 1, Class III, and Class II div 2 malocclusions which were 48.1%, 26.3%, 22.4%, and 3.2% respectively (Soh *et al.*, 2005).

A retrospective study was done by Lew (1993), a total of 1050 Chinese school children living in Australia in the age group of 12 to 14 years with all subjects in the permanent dentition, no history of orthodontic treatment, and no systemic abnormalities. Each subject was examined while seated on a dental chair. The intra-oral examination was accomplished using a dental mirror, periodontal probe, and millimeter rule and the anterior-posterior arch relationship was evaluated according to Angle classification based on the molar relationship. The distributions of normal occlusion were 7.1% and the prevalence of malocclusions were 58.8%, 18.8%, 12.6%, and 2.7% for Class I, Class II div 1, Class III and Class II div 2 respectively (Lew *et al.*, 1993).

In Nepal, a study was conducted among schoolchildren aimed to evaluate the prevalence of malocclusion and orthodontic treatment needs which was done by Singh and Sharma (2014). A total of 2074 subjects (1149 males and 925 females) in the age group of 12 to 15 years from twenty schools were selected. Angle classification based on the molar relationship was used, and results showed that 48.5%, 29.3%, 3.3%, and 4.3% for Class I, Class II div 1, Class II div 2 and Class III malocclusions respectively and normal occlusion was observed as 14.42% (Singh and Sharma, 2014).

Another cross-sectional Nepali study was performed by Sharma (2011), in Sunsari district of Nepal involving 350 patients (106 males and 244 females) in the age group of 8 to 36 years by the Department of Orthodontics, College of Dental Surgery Koirala, Institute of Health Sciences Dharan, Nepal. Angle classification based on the molar relationship was used, and the distribution of malocclusion was found as 62.3%, 29.4%, and 8.2% for Class I, Class II and Class III malocclusions respectively (Sharma, 2011).

In Bangalore, India, a study was conducted among 745 school children (388 males and 357 females), the age group of 8 to 12 years with permanent dentition who were selected randomly from twelve different schools in Bangalore city. All subjects were examined by a single operator using mouth mirror and flashlight with occlusal relationships assessed in centric occlusion, which was attained by asking the subjects to swallow and then to bite on his or her teeth together. Angle classification based on the molar relationship was used, and normal occlusion was detected in 29.0% of the subjects and 71.0% had malocclusions. Class I malocclusion was found in 61.6%, Class II div 1, 6.8%, Class II div 2, 1.6%, and Class III 0.6% (Das and Venkatsubramanian, 2008).

Another Indian study was carried out among children and adolescents' group from several schools in Leh, India. This study consisted of 691 children (311 males and 380 females) in the age group of 10 to 18 years. Angle classification based on the molar relationship was utilized to assess the occlusal relationship and the distribution of malocclusion which was 87.4%, 8.7%, 1.4 %, and 2.5% for Class I, Class II div 1, Class II div 2, and Class III malocclusions respectively (Singh *et al.*, 2015).

2.4.2 Prevalence of malocclusion in Middle East population

A study among Saudi males was found the distributions of malocclusion were 62.3%, 28.4%, and 9.3% for Class I, Class II and Class III malocclusions respectively. This epidemiological study was conducted on 1820 Saudi schoolboys in the age group of 15 to 17 years with permanent dentition in Aseer region, Angle classification based on the molar relationship was used for evaluating malocclusion (Meer *et al.*, 2016).

A former study in (2012), among 2400 Yemeni 14-year-old adolescents, equally distributed by sexes who participated in a study to evaluate the prevalence of malocclusion. A multi-stage stratified sampling technique was used in five geographical areas (north, south, middle, east and west) of Yemen and clinical examination was performed using disposable mouth mirrors and under natural lighting. The incisor relationship according to BSI was done to assessing the prevalence of malocclusion. The distribution of malocclusion was detected as 56.0%, 29.4%, 1.3%, and 13.3% for Class I, Class II div 1, Class II div 2, and Class III malocclusions respectively (Al-Maqtari, 2012).

A prior study in (2010), was comprised of 700 patients (309 males and 391 females) in the age group of 6 to 14 years (mean age of 8.9 years) who attended the Department of Orthodontics, Shiraz University of Medical Sciences, Iran, this study was conducted to determine the prevalence of malocclusions in the Shiraz population of Iran. All subjects came from the southern regions of Iran and were randomly selected excluding subjects with inadequate data, history of previous orthodontic treatment, craniofacial deformity, and systemic disease. Angle classification of malocclusion was used and the distribution of malocclusion was found as 52.0%, 32.0%, and 12.3% for Class I, Class II, and Class III malocclusions respectively (Oshagh *et al.*, 2010).

2.4.3 Prevalence of malocclusion in Caucasian population

A Turkish study was performed by Gelgör (2007), a total of 2329 adolescents (1125 males and 1204 females) in the age group of 12 to 17 years (mean age of 14.6 years) in Central Anatolian, Turkey. Subjects were randomly selected while they attended the Dental Health Centre of Kirikkale in Central Anatolia, Turkey. Angle classification based on the molar relationship was utilized and it was shown that normal occlusion

was presented as 10.1%, Class I 34.9%, Class II div 1, 40%, Class II div 2, 4.7% and Class III 10.3% malocclusions of the subjects (Gelgör *et al.*, 2007).

A study was conducted by Silva and Kang (2001), among 507 Latino, in the USA, individuals were prospectively assessed between 1995 and 1999 in California. Study subjects were selected repeatedly for inclusion in the study because they were seen in the dental office for treatment. All subjects who met the following inclusion criteria were included in the sample such as; age 12 to 18 years old, Latino ethnic background, secondary dentition and excluded any remaining deciduous teeth, multiple missing teeth, and previous history of orthodontic treatment. Angle's classification based on the molar relationship was used to define the anteroposterior relationship of the maxillary and mandibular first molars during maximum intercuspation. The distribution for Class I normal occlusion has shown 6.5%, the prevalence of malocclusion was shown in Class I malocclusion 62.9%, Class II div 1, 20.3%, Class II div 2 1.2% and Class III 9.1% (Silva and Kang, 2001).

2.4.4 Prevalence of malocclusion among African population

In Tanzania, a study was performed by Mtaya (2009), in school children in different areas of Tanzania to evaluate the association of prevalence of malocclusion with the socio-demographic characteristics, caries experience, and level of oral hygiene. A total of 1601 (632 males and 969 females) subjects in the age group of 12 to 14 years with permanent dentition were randomly selected using stratified proportionate two-stage cluster sampling design from 16 schools out of 220 public schools from urban and rural areas of Tanzania excluding subjects with previous orthodontic treatment. Angle classification based on the molar relationship was used and the distribution of

malocclusion was found as 93.6%, 4.4%, and 2.0% for Class I, Class II, and Class III malocclusions respectively (Mtaya *et al.*, 2009).

In Rwandan, a study was conducted by Sandeep and Sonia (2012), among 243 patients (124 males and 119 females) in the age group of 10 to 30 years with permanent dentition who visited the Dental Department of King Faisal Hospital, Rwanda to generate quantifiable data on the pattern of dental malocclusion among the population of Rwanda. Subjects with craniofacial deformity and previous history of orthodontic treatment were excluded from the study. The anteroposterior relationships were assessed using the Angle classification based on the molar relationship. The distribution of malocclusion was shown as Class I 56.5%, Class II div 1, 33.0%, Class II div 2, 0.8%, and Class III 9.7% (Sandeep and Sonia, 2012).

2.5 Craniofacial morphology

The morphological information obtained from cephalometric can be an analysis of craniofacial structure in two views; the posterior-anterior view (PA view) and the lateral view (LA view) (Cheng *et al*., 2008). Moreover, the cephalometric was used for measuring the facial dimensions, proportional and monitoring development variation during growth and treatment (Nebbe *et al.*, 1998).

The irregularity of the craniofacial skeleton causes aesthetic and functional complications that needed more awareness (Obwegeser and Makek, 1986). The asymmetry of craniofacial is present in patients and non-patients. The differences that occur in variable grades in the population may cause interference with the esthetic appearance and normal dental function or may be so insignificant that it cannot be identified by simple observation. The appearance of the craniofacial asymmetry can be associated with heredity as well as to the functional activity of the skeletal muscular system (Rossi *et al.*, 2003).

The change of occlusion from ideal to severe malocclusion leads to reflects in bone progress, neuromuscular maturation, and dental development (Moyers and Wainright, 1977). Malocclusion is the straight result of the interaction between the position of teeth and the position of the jaw. However, the intermaxillary relationships were affected by the teeth position. Skeletal inconsistency shows a better result when preserved during the growth period by used the cephalometric analysis to show a significant difference between dentofacial proportions (Kuramae *et al.*, 2007).

Several investigators attempted to describe and to verify a convinced correlation between facial features, malocclusion possessions and the various components of biometric anatomical landmarks in Chinese population (Cooke and Wei, 1989; Lew,

1994; Zeng *et al.*, 2007), Japanese population (Iizuka, 1957; Miyajima *et al.*, 1996), black American population (Connor and Moshiri, 1985; Fonseca, 1978), Caucasian population (Mills, 1987) and Arab population (Al-Barakati, 2007; Al-Jasser, 2005; Al-Khateeb and Al-Khateeb, 2009).

These kinds of trials are useful for predicting the features which that become helpful for numerous orthodontic treatments need of the different ethnic groups with the development of orthodontic service overall. The radiographic analysis of the craniofacial skeleton is a scientifically initiated method for diagnosing malocclusion and planning orthodontic treatment (Wu, 2007; Zeng *et al.*, 2007).

2.5.1 Development of craniofacial

In general, the growth of craniofacial structure can be reflected in five separate phases following the outlining of the germ layers which has shown a neural crest at the neuroectoderm border that leads to a passage of the cranial neural crest into the presumptive facial primordia (Creuzet, 2005; Johnston, 1966; Le Lièvre, 1978; Le Lièvre and Le Douarin, 1975; Sadaghiani and Thiébaud, 1987). Consequently, the regional production of neural crest migrates to the creation of outgrowths called facial prominences. Following this, facial prominences combine to indicate a mature form of the face. Ultimately, the embryonic face was formed by reversing the growth of the skeleton (Knecht and Bronner-Fraser, 2002; Sauka-Spengler and Bronner-Fraser, 2008).

Furthermore, a neural crest drifts into the face and the cranial placodes. The placodes with some assistance from a neural crest that provides rise to the apparatuses of sensory structures such as olfactory glia, the lens of the eye and cranial ganglia. The optic and olfactory placodes and precisely several growth factors would then become an impact

on the development of the face (Baker and Bronner-Fraser, 2001; Schlosser, 2006; Streit, 2004). The associations between the development of the base of the skull and maxillofacial apparatuses have been established in facial development reports (Björk, 1955; Enlow and McNamara, 1973). Morphology of the base of the skull may be a significant factor in the anteroposterior relationship of the maxilla and mandible as well as in defining Class III malocclusion (Chang *et al.*, 2014; Guyer *et al.*, 1986; Sanborn, 1955).

2.5.2 Cephalometric analysis

The cephalometric analysis is a beneficial investigative implementation to regulate facial shape and growth pattern, which could be used by clinicians to establish facial disharmonies in order to compact therapeutic processes during treatment and adjust the facial development (Kuramae *et al.*, 2007). The cephalometric radiograph has been utilized widely to study facial outline and to progress the strategies to assist in orthodontic diagnosis and treatment planning, whereas it can also be operated to assess craniofacial growth and for other requests in orthodontic research (Ajayi, 2005).

Jarabak analysis (Jarabak and Fizzell, 1972), was well-defined as cephalometric science that was useful to determine the dentofacial complexities and evaluating the variations which can disturb the total complex with the estimation of individual progress. Jarabak cephalometric analysis is a newly-introduced measurement that was adopted and modified from Bjork (Björk, 1969) which was useful in scientific situations. Jarabak cephalometric analysis furthermore reflects the vertical relationship (deep bite and open bite), anterior-posterior skeletal relationship and intermaxillary relationships, by selecting the cranial base as a reference structure. It can also be used for appraising anomalies and morphological features and assessing the facial growth outline (Björk, 1955).

Steiner analysis was proposed by Cecial Steiner in 1953 which utilized the Sella (S), Nasion (N) plane as a point of horizontal reference instead of the Frankfort plane. Therefore, SN lies on the mid-sagittal plane of the skull and minimized any displacement which will happen by lateral movement of the head. These two points Sella (S) and Nasion (N) were easily identified on the radiograph. In addition, this method could compromise the position of an incisor on skeletal discrepancy (Steiner, 1953).

Tweed's analysis was described by Charles H Tweed in 1954 which was used based on the inclination of mandibular incisor to basal bone and then associated with the vertical relation of the mandible to cranium which was constructed as a triangle performed by the lower central incisor, mandibular plane and Frankfort Horizontal plane (Tweed, 1954).

2.5.3 Craniofacial morphology among Asian population

A study was undertaken by Wahab (2013), among 760 patients, the age group 17 years in Kadazan Dusun, Malaysia the major ethnic group in Sabah, Malaysia, to evaluate the skeletal outline and the malocclusion of Kadazan Dusun ethnic patients who requested for orthodontic treatment. It was a retrospective study of the lateral cephalometric radiographs and study models that were selected from the year 1998 to 2010. Those samples were selected from two government dental clinics; Luyang Hospital Dental Clinics, Sandakan Hospital Dental Clinics and from two private orthodontic clinics Smile Orthodontic Clinic and Damai Dental Clinics in Sabah.

The patient had malocclusion with no history of orthodontic treatment, samples excluded were cleft lip and palate, poor superiority radiographs and broken study model. The examination method of this research is divided into two main parts; first,

estimation of the skeletal outline by analyzing the lateral cephalometric radiographs and then evaluation of the malocclusion of the samples by analyzing the study models. The data were analyzed using the Statistical Package for Social Science (SPSS) version 18.0 and the established descriptive statistic with frequency and percentage. Pearson's correlation coefficient when $P<0.05$ was set as a statistically significant difference.

The outcome found that maxillary skeletal relationships had a higher proportion of samples with the regular maxilla, followed by a retrognathic maxilla and a prognathic maxilla. Although the mandibular skeletal relationship had shown of the total samples have normal mandible, followed by the prognathic mandible and retrognathic mandible, the vertical dimension revealed that more than half of the overall samples have typical vertical dimension, followed by increased vertical dimension, and reduced vertical dimension. The intermaxillary relationship found that practically, half of the total samples had Class I Skeletal shape, followed by Class II skeletal shape and Class III skeletal shape. The dentoalveolar relationships displayed that half of the whole sample had the normal inclination of the lower incisor, followed by proclined lower incisors and retroclined lower incisors (Wahab *et al.,* 2013).

Another previous study in Malaysia was conducted by Mohammed (2011), among 70 subjects from pure Malay ethnic group in Malaysia. The purpose of the study was to attain the cephalometric averages for Malaysian Malay through Steiner's analysis and compared with Caucasian norms. The age group of between 20 to 24 years old, with equally distributed genders of 35 females and 35 males. The overall sample composed of the students and patients in the Faculty of Dentistry University Technology Mara. The study excluded ten subjects due to the poor quality of the record. These subjects were all volunteers. The descriptive statistic of all lateral cephalometric radiographs was used when the significant level for this study was set at $P<0.05$.

The result of this study showed that the maxilla and mandible of Malaysian Malay are set more forward than Caucasians. They also demonstrate bimaxillary dental protrusion when related to Caucasians. The Malaysian Malay has more protrusive upper and lower lips, the chin showed less prominent when compared to Caucasian. Malaysian Malay have higher of both the mandibular planes and the occlusal planes, mandibular posterior rotation when associated with the Caucasian (Mohammad *et al.*, 2011).

A previous study was conducted by Chang (2005), in Taiwan, to examined the morphologic features of the cranial base in children with Class III malocclusion by using the total of 100 Lateral Cephalogram from children with an equal number of males and females, in the age group of 9.4 to11.5 years, with Class III malocclusions, and were associated with 100 samples with normal occlusions. These radiographs were attained from records at the Department of Orthodontics, Kaohsiung Medical University, Taiwan. The cephalograms were traced by a single examiner to identify and digitize ten landmarks on the cranial base. The seven angular and 18 linear measurements were performed using cephalometric analysis which has shown in (Figure 2.3). All data were entered on SPSS and two groups of cephalometric measurements were compared by using a t-test for independent samples for showing the statistical significance when P-value set at < 0.05. Multivariate hoteling's T2 test was used to evaluate errors included in cephalometric tracing and digitizing. The Dahlberg formula was used to calculate the errors between the two measurements.

The study concludes that there are shortening and acute angles of the cranial base, and a reduced angle between the cranial base and mandibular ramus may be related to the formation and facial morphology of Class III malocclusion (Chang *et al.*, 2005).

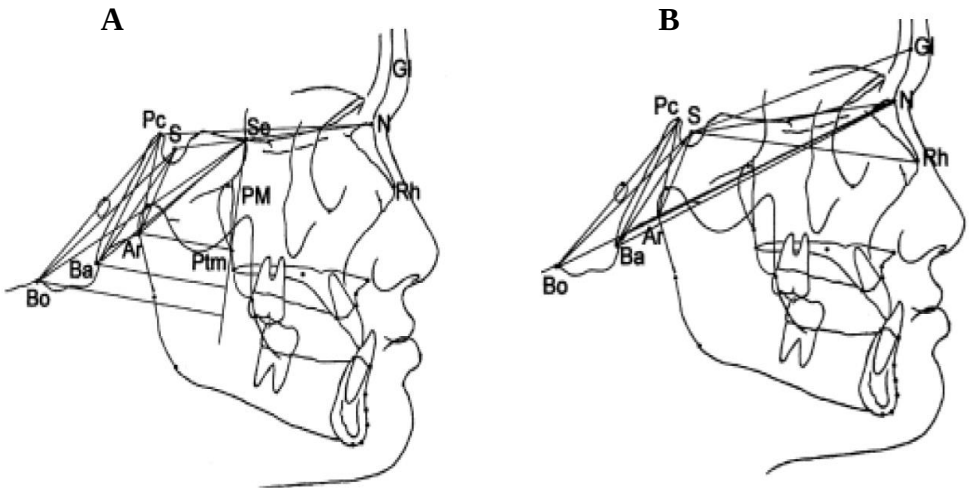


Figure 2.3 Cranial linear and angular variables used for cephalometric analysis (Chang *et al.*, 2005).

(A) Linear variables (mm): N-Ar; N-Ba; N-Bo; S-N; S-Gl; S-Rh; S-Ar; S-Ba; S-Bo; Pc-Ar; Pc-Ba; Pc-Bo.

(B) Posterior-maxillary (PM) plane: Se-Ptm. Linear variables (mm): Ar-PM; Ba-PM; Bo-PM; Se-Ar; Se-Ba; Se-Bo. Angular variables (°): N-S-Ar; N-S-Ba; N-S-Bo; Gl-N-Rh.

Another study in Taiwan was conducted by Xu (2018), a total of 30 patients were examined to evaluate the morphological changes of skeletal Class III malocclusion in mixed dentition with protraction combined activities. A total of 30 patients' samples (15 females and 15 males) were selected from 2014 to 2017 in the department of orthodontics, Shanxi Medical University Stomatological Hospital. The inclusion criteria involved in this study were; age group between 6 to 10 years, skeletal Class III malocclusion and anterior crossbite and reverse overjet. Meanwhile, the exclusions criteria were; previous history of orthodontic treatment or trauma, oral maxillofacial deformities and any systemic diseases influencing oral maxillofacial development.

The cephalometric analysis was used to obtain the measurement index of hard tissue and soft tissue. The data were managed by SPSS 22.0 software and the paired t-test

was utilized before and after treatment when the p-value was set at $P<0.05$. The finding After treatment showed SNA was increased indicating that the sagittal relationship between the maxilla and mandible which was significantly enhanced. MP-SN increased showed growth and development during treatment. U1-SN increased indicating that the lower anterior teeth no obvious after the shift and tilt. Ns-Sn-Pos increased by the upper lip forward, the upper lip thickness decreased (Xu *et al.*, 2018).

A study was undertaken by Alam (2013), in Bangladesh to recognize the craniofacial structures of men and women adults from Bangladesh using Tweed's and Wit's analysis and compare the mean difference with the established value of Tweed's and Wit's cephalometric normal. A total of 100 identical lateral cephalometric radiographs of Bangladeshi adults (50 females and 50 males) were analyzed, the age group between 18 to 24 years. Inclusion criteria were Class I incisor relationship with no skeletal abnormality, no crowding, and no previous orthodontic treatment. The cephalometric landmarks were situated and defined in (Figure 2.4). The tracing was done according to Tweed's and Wit's analysis.

Consequently, this study found that the Bangladeshi females had a considerably reduced FMA, FMIA but meaningfully increased IMPA. However, in Wit's appraisal, the Bangladeshi males were found to have a much larger mandibular plane angle; SNA and SNB (Alam *et al.*, 2013).

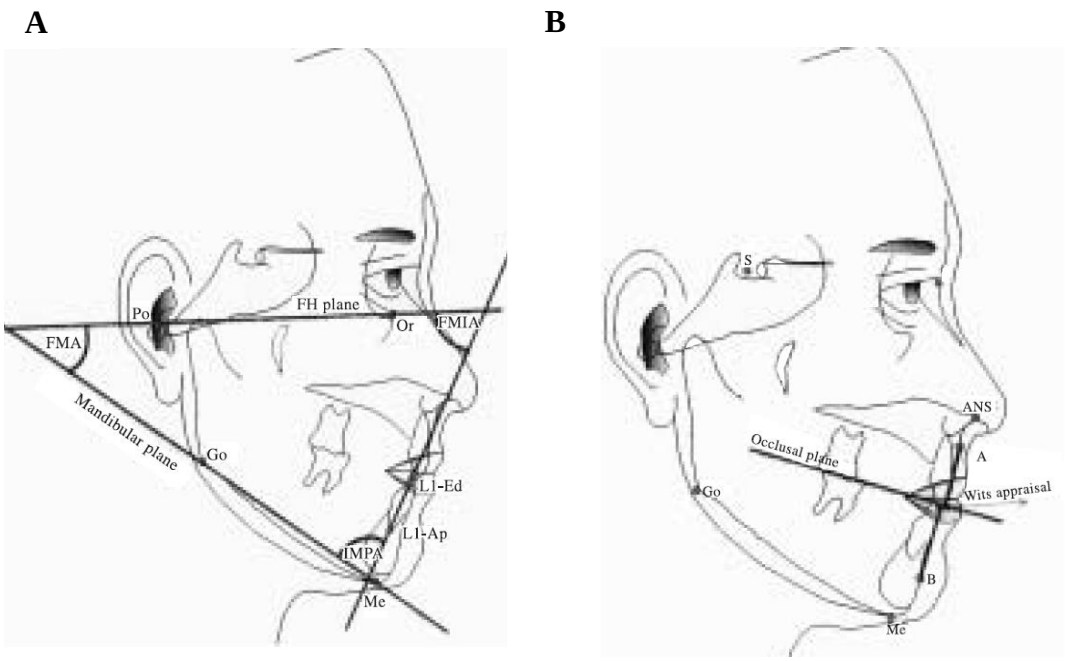


Figure 2.4 Tweed's and Wit's analysis of lateral cephalometric radiograph for Bangladeshi (Alam *et al.*, 2013).

(**A**) Cephalometric reference lines and angles being used in Tweed's analysis.
(**B**) The major landmarks used in Wit's analysis: Sella (S), Nasion (N), point A(A), point B(B), Menton (Me), gonion (Go).

A study was conducted by Agarwal (2013), in India among 103 patients in the Department of Orthodontics, Rajasthan Dental College, Hospital Jaipur, India. The purpose of this study was to estimate the alteration in the cranial base flexure between the skeletal of dental Class I and Class II div 1, malocclusion. The lateral cephalometric radiographs were attained from the primary archives of 103 patients with Class I malocclusion (n=52) divided into (25 female and 27 male) and Class II div 1, (n=51) divided into (26 female and 25 male), which were accessible in searching for the orthodontic treatment. The sample included in this study was divided into two groups; group 1: Skeletal Class I malocclusion with an ANB angle of 2 ±, overbite and overjet and slight crowding of both arches. Group 2: Skeletal Class II div 1,

malocclusion with ANB angle of +5° and increased overjet. Patients who were having any oral habit were excluded from the study.

All the radiographs were hand traced and measured with the analysis of the variables' landmarks such as Point A, Point B, Sella (S), Nasion (N), Articulare (Ar). The angular measurements were for the calculation of the sagittal growth outline; ANB. The angular measurements were also for the estimation of the cranial base flexure; N-S-Ar. The t-test was used to compare between the two groups and when the sign was a seat at $P<0.05$. The cranial base flexure was assessed based on the N-S-Ar angular measurements which showed a steady rise from Class I to Class II div 1, malocclusion. This study declined to find any differences in the cranial base angle among sagittal malocclusions (Agarwal *et al.*, 2013).

A study was performed by Kwon (2006), in South Korea among 42 patients with dentofacial deformity at the Department of Oral and Maxillofacial Surgery, Kyungpook National University Hospital, South Korea. The groups of 22 females and 20 males with dentofacial deformity and divided into two groups based on the deviation of the chin such as; Asymmetry group (n= 24, age 23.4) and Non-asymmetry group (n=18, age =22.6). These two groups were associated with three-dimensional (3D) CT reformatted images via a 3D visualization and analyzing program which displayed the differences between these two groups.

The correlation between the cranial base and the maxillomandibular asymmetry was evaluated statistically by using SPSS throughout the t-test to compare the significant difference when the P-value was set at <0.05 and the correlation analysis to detect the relationship between the cranial base and maxillomandibular asymmetry. The outcome

found the degree of cranial base asymmetry in the Asymmetry group was not statistically different from the Non-asymmetry group.

The asymmetric condyle position was observed to be related to skull-base features. The 3D position of the cranial base and condyle was not closely associated with mandibular asymmetry. Although the results showed the cranial measurement of variables were not the main factors that established the degree of facial asymmetry, it appears that the mandibular skeletal factors, functional or intrinsic asymmetric growth potential had exacerbated the influence of cranial asymmetry throughout the growth stage (Kwon *et al.*, 2006).

2.5.4 Craniofacial morphology among of Middle East population

In Egypt, a study was conducted by Adel (2016), at Suez Canal University, Egypt. The aim of this study was to estimate the craniofacial morphology of Egyptian adults undergoing orthodontic. The material used for this study was lateral cephalometric radiographs which were taken from 300 Egyptian subjects divided into (82 males and 218 females), age group between 18 to 55 years. The subjects excluded had congenital disorder; cleft lip and cleft palate.

The lateral cephalograms radiographs were identified as 19 hard tissue points and 5 soft tissue points. The 20 angle and 7 linear measurements on lateral cephalograms were analyzed by using cephalo software (Reaza Net co, Ltd, Tokyo, Japan). All data were entered in the Statistical Package for Social Science version 23, which used an independent t-test used to compare the differences between two genders in the cephalometric variables. The outcome from this study exhibited that the Egyptians had the tendency towards skeletal Class II malocclusion with more retrognathic mandible,

whereby showing the facial profile as a convex outline and proclined of the lower incisor (Adel *et al.*, 2016).

In Jordan, a study was performed by Al-Khateeb (2009) to define and investigate the skeletal and dental characteristics associated with Class II div 1, and Class II div 2 malocclusions in the anteroposterior and vertical dimension, at University of Science and Technology. It was a retrospective study, with a total of 551 of lateral cephalograms and study cast divided into two groups; group 1: Class II div 1, had 293 films, group 2: 2 Class II div 2 had 258 films.

These two groups were examined and analyzed and were used in the British standard institute Classification to assess the different kinds of malocclusion. The tracing and analysis were carried out by one examiner using Vista dent AT software (GAC International Inc, Bohemia, NY). The mean and standard deviation for each variable were calculated using the statistical package for social sciences (SPSS version 15), while the t-test was used to compare between the different measurements.

This study reported both malocclusions had prognathic maxilla. The mandible has shown retrognathic in Class II div1 and orthognathic in Class II div 2. Vertically, lower anterior facial height was significantly reduced in subjects with Class II div 2 when compared with subjects with Class II div 1, who displayed a significantly increased lower anterior facial height. In Class II div 1, the lower incisors were proclined and the interincisal angle was decreased, while in Class II div 2 the lower incisors were at a normal inclination and the interincisal angle was increased (Al-Khateeb and Al-Khateeb, 2009).

Another study was previously conducted in Saudi Arabia by AlKhudhairi and AlKofide (2010), among of 24 Saudi families to estimate the craniofacial features in parents and their offspring and 24 Saudi families; for every individual family, it involved the father, mother, son, and daughter, each family member was required to have the Lateral cephalometric radiographs which identified 15 angular measurements and 12 linear measurements and 1 proportional cephalometric trait which were then analyzed. The descriptive analysis was calculated for each cephalometric measurement which was performed using two statistical procedures: the heritability test and the Pearson correlation coefficient. The outcome in this study has shown the most similar angular measurements between parents and offspring which were associated with mandibular variables such as MP-FHA, SN-Ba, MP-SN, and SN-Pog; facial height dimensions and mandibular body length were amongst the highest like linear variables. The lower facial height was shown as a greater percentage of parents with proportional measurements (AlKhudhairi and AlKofide, 2010).

2.5.5 Craniofacial morphology among of Caucasian the population

In former, a retrospective study was done by Sidlauskas (2006), at Kaunas University of Medicine, Lithuania. The aim of this study was to assess prepubertal children with Class II div 1, malocclusion, to evaluate maxillary and mandibular skeletal positions in evaluation with normal growth values by means of cephalometric measurements by clinical physicians.

The materials used in this study were dental cast and cephalometric radiographs on a total of 86 patients (49 females and 37 males), the age group of between 9 to12 years. The analysis of cephalometric radiographs were taken from ten variable landmarks such as SNA, SNB, ANB, Wits appraisal, mandibular plane angle to cranial base

(SN/MAN), mandibular plane angle to maxillary plane (MAX/MAN), maxillary incisor to maxillary plane (UI/MAX), mandibular incisor angle to mandibular plane (UI/MAND), overjet, and overbite. The result of this study revealed that Class II div 1, malocclusion was found to have the most variation in dental and skeletal morphology. The vertical skeletal jaw relationship was assessed by two angles: Mandibular plane to the cranial base angle (SN/MAN) which was smaller in a patient because 60% had retrognathic mandible. Although mandibular plane to maxillary plane (MAX/MAN) angle was reduced, therefore maxillary prognathism for 55.8% of the patients and the most common features were reduced vertical jaw relationship in Class II div 1 (Sidlauskas *et al.*, 2006).

Another study was conducted at the University of Geneva, Switzerland by Staudt and Kiliaridis (2009), has shown Class III malocclusion with different representation such as skeletal and dentoalveolar. The sample comprised of 3358 young males who were examined based on the molar relationship regrading to Angle's classification and the cephalometric radiographs were involved in this study using the software view box version 3.1.1. The landmarks which were involved in analyzing; maxillary and mandibular relationships (ANB-Wits) with positions (SNB-SNA), and comparative proportions (Go-Pg and ANS-PNS related to SN) were recognized in (Figure 2.5).

The statistical analysis was performed using SPSS and t-test to assess the various variables between skeletal and dental. The result for this study showed that overall 75.4% of the samples with Class III malocclusion had a skeletal origin which had found the difference was mostly (47.4%) due to mandibular prognathism or growth excess (10.5% prognathism, 15.8% macrognathia and 21.1% both) or, although the maxilla was 19.3% (8.8% micrognathia, 10.5% retrognathism) and also the combination of maxillary and mandibular conflict in 8.7%. The dental compensation

was communal with proclined maxillary incisors in 42.1% and retroclined mandibular incisors in 26.3% (Staudt and Kiliaridis, 2009).

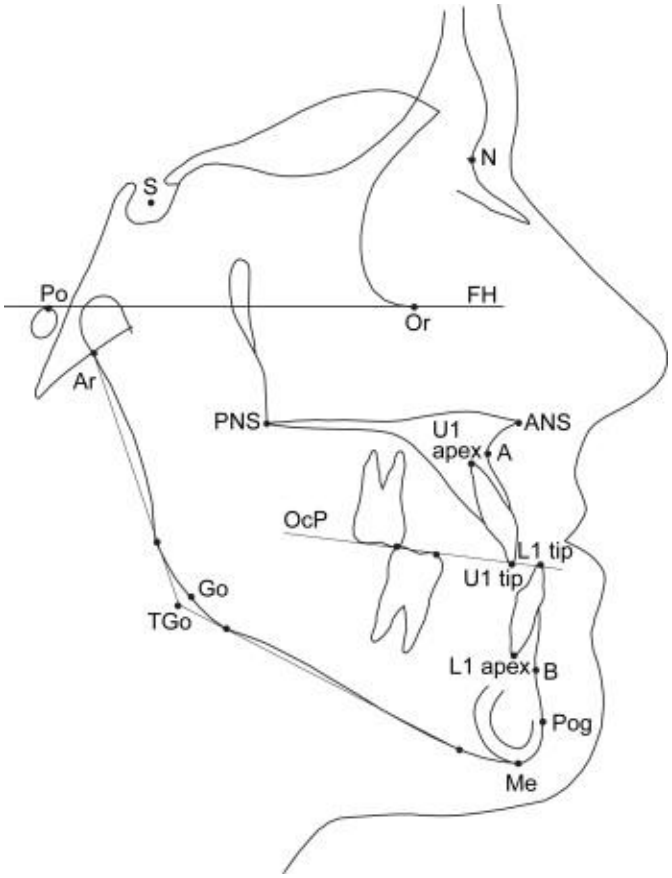


Figure 2.5 Landmarks digitized on skeletal and dental structures on the lateral Cephalogram in Switzerland (Staudt and Kiliaridis, 2009).

In Germany Proff (2008), was conducted a previous study to estimate the cranial base configuration in skeletal Class III patients. The total of 54 lateral radiographs of skeletal Class III patients and 54 corresponded controls (Class I, Class II div 1, Class II div 2), the age group of 14 to 24 years were analyzed retrospectively. In contrast, overall cranial base length has shown in (Figure 2.6); the anterior section (N-S) and posterior section (S-Ba, S-Ar) recorded to show a significant reduction in Class III patients. The significantly showed more acute angles Ca-S-Ba and Se-S-Ba exhibited increased cranial base flexure. The anterior condylar displacement was displayed by a significant reduction of Ar-Ca and Se-S-Cd which leads to a significant increase in the mandibular length. The outcomes are consistent with the inadequate ortho-cephalization hypothesis of Class III morphogenesis (Proff *et al.*, 2008).

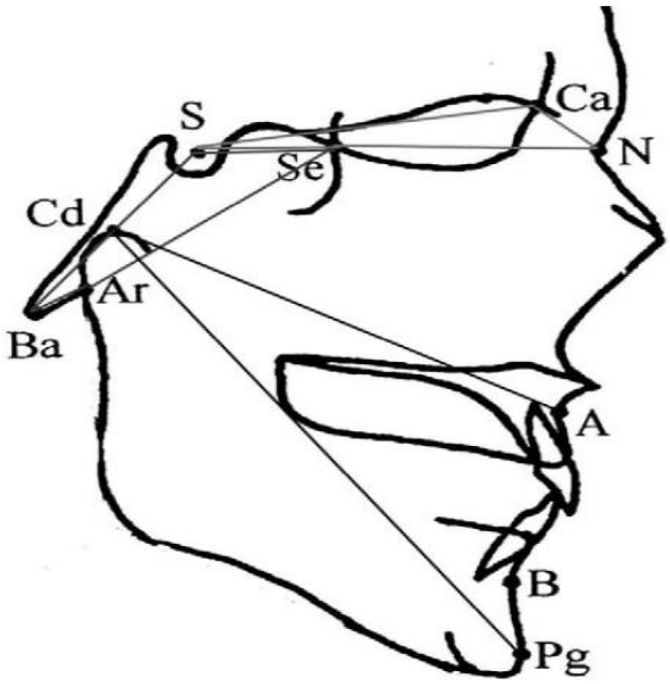


Figure 2.6 Cephalometric measurement points and lines in Germany (Proff *et al.*, 2008).

CHAPTER THREE

METHODOLOGY

3.1 Study design

The study design for this research is divided according to the objectives which are:

- For objective 1: This is a cross-sectional descriptive study which aims to determine the prevalence of incisor relationship among school children in the age group of 12 to 18 years in Kota Bharu, Kelantan.
- For objective 2: This is a cross-sectional study to compare the craniofacial morphology of Class I, Class II and Class III malocclusions among Malay patients in Hospital USM, the age group of 12 to 25 years. Data were retrospectively obtained from the archive of Orthodontic Clinic, School of Dental Sciences, Hospital USM between 2014 to 2018.

3.2 Reference population

A school children age group 12-18 years old in Kota Bharu, Kelantan. Malay patients 12-25 years old with Class I, Class II and Class III malocclusion in Hospital USM.

3.3 Source population

For objective 1: secondary government schools' children in Kota Bharu were selected to be part of this study.

For objective 2: patients record who seeking for treatment in Hospital Universiti Sains Malaysia.

3.3 Ethical consideration

Ethical approval was obtained from the Universiti Sains Malaysia JEPEM HUSM Human Research Ethics Committee: USM/JEPEM/17120693 and Ministry of Education for visiting schoolchildren (Appendix C, E). The permission was obtained from the Hospital Director of Hospital USM for assessing the patient folder and lateral cephalometric radiograph (Appendix D).

3.4 Inclusion and Exclusion Criteria

Subjects included in this study have the criteria presented in (Table 3.1).

Table 3.1 Summary of inclusion and exclusion criteria of the participant.

Objective 1		Objective 2	
Inclusion Criteria	Exclusion Criteria	Inclusion Criteria	Exclusion Criteria
1. Age group between 12 to18 years.	1.Multiple missing teeth.	1. Standardized lateral cephalometric radiographs.	1.Congenital deformities and/or systemic illness which affected the craniofacial morphology.
2. Secondary dentition from right 1^{st} molar to left 1^{st} molar.	2.Filling.	2. Select lateral cephalometric x-ray from the study model.	2. History and under orthodontic or orthopedic treatment.
3. Permanent incisors teeth.	3. Congenital deformity such as cleft lip and palate.	3. Age group between 12 to 25 years.	3. Poor quality of the lateral cephalometric radiograph.
		4. Malays.	4. History of facial trauma.

3.5 Sample size calculations

3.5.1 For Objective 1

The calculation of sample size to estimate the prevalence of incisor relationship was done by using a single proportional formula which was described as follows**:**

$$n = \left(\frac{z}{\Delta}\right)^2 \times P(1-P)$$

with

n= sample size required.

Δ= precision of the study according to WHO guidelines oral health survey =5

z= standard normal deviation =1.96, at 95% confidence level.

P= proportion of people for the prevalence of incisor relationship was taken as Class I 48.1%, Class II div 1, 26.3%, Class II div 2, 3.2%, Class III 22.4% (Soh *et al.*, 2005).

Each variable was having different p-value as given in the (Table 3.2).

Table 3. 2 Sample size calculation by using a single proportional formula.

Variables	P	**n**
Class I	0.48 (Soh *et al.*, 2005)	383
Class II div 1	0.26 (Soh *et al.*, 2005)	296
Class II div 2	0.03 (Soh *et al.*, 2005)	44
Class III	0.22 (Soh *et al.*, 2005)	287

The sample size calculation for all the variables was done separately and the largest sample size was taken which is 383.

There was a possibility of 20 % missing data from the record.

$$\text{Missing data } 20\% = \frac{383}{(1\text{-}20\%)} = 479$$

Hence, the result from this calculation was 479, as we conducted study multicentral in Kota Bahru, so we manage to collect 1300 subjects which were fulfilled the inclusion criteria of this study. The high number of subjects was the strength of our study to represent the prevalence of incisor relationships in the local adolescent age group. As larger sample size presenting more precision and accuracy (Singh and Masuku, 2014).

3.5.2 For Objective 2

The sample size was calculated using PS software version 3.1.2 (Dupont, 1997), has showed in (Figure 3.1) for comparison of craniofacial morphology of malocclusions, with parameters adjusted as power of the study=80%, alpha=0.05, expected difference = 1.9 mm, and standard deviation (SD) = 3 mm (Proff *et al.*, 2008). The calculated sample size required for each group was 40. Hence, the sample size selected was 40x3 = 120 subjects (Class I = 40, Class II= 40, and Class III = 40).

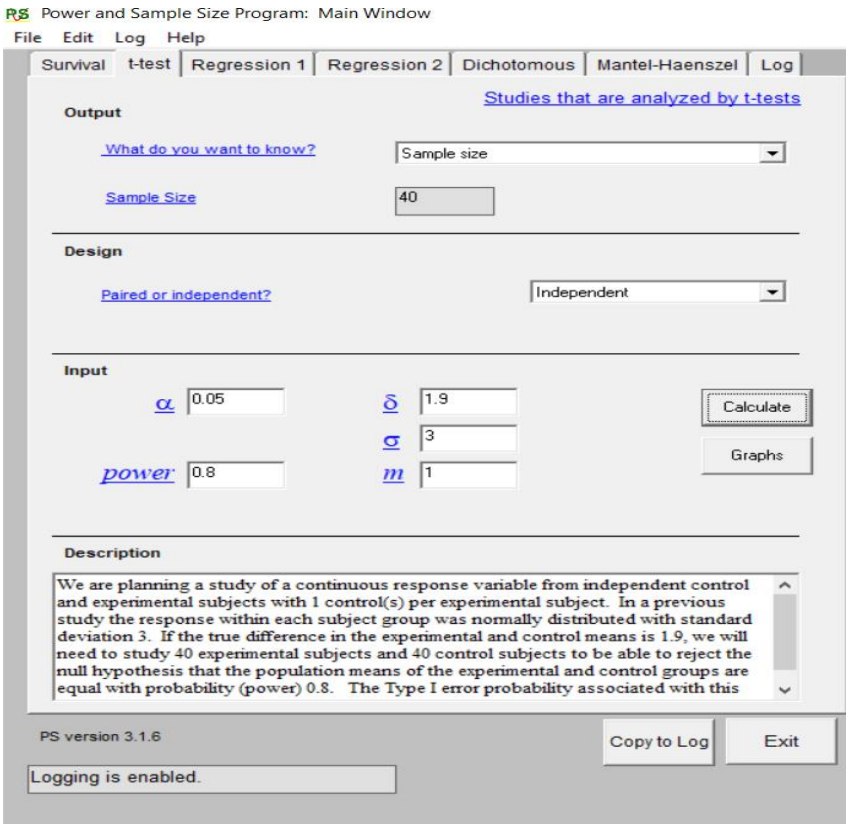


Figure 3.1 PS software version 3.1.2 for calculation sample size.

3.6 Sampling Method

The convenience sampling method was used to select the required number of subjects from form one to form four for the prevalence of incisor relationships among nine government school children. These students were included from nine different schools among Kota Bharu, Kelantan. The selection was done based on the inclusion and exclusion criteria.

All subjects were collected from the archive of Orthodontic Clinic, School of Dental Sciences, Hospital USM. All samples were selected by convenience sampling method according to the inclusion and exclusion criteria to fulfil the required number of the previously calculated sample size. The collection was done after the examiner had observed 270 cast models evaluate the malocclusion. Furthermore, the selection of 120 cast model was done for the determination of malocclusion as per inclusion criteria. The lateral cephalometric radiograph was extracted accordingly. The data of subjects were entered SPSS software to randomly selected them by the digital method.

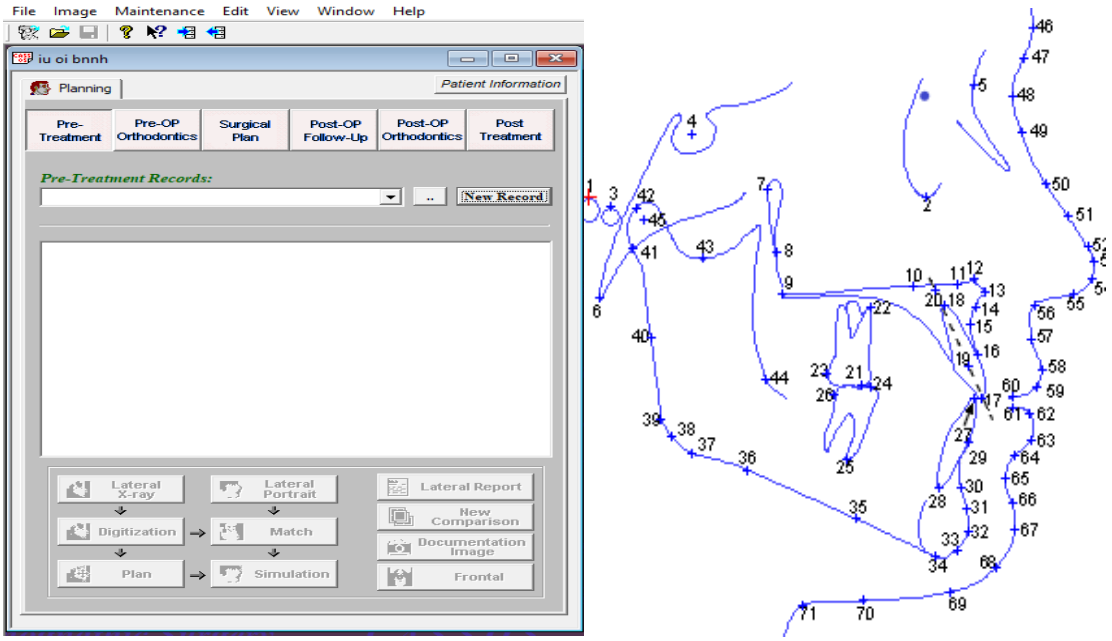
3.8 Research tools

The tools included in this study were divided according to the objective:

1. To determine the prevalence of incisor relationship among schoolchildren was used:
    a) Disposable mouth mirror and flashlight.
2. To evaluate the craniofacial morphology of different classes of malocclusion was used:
    a) Lateral cephalometric radiographs (Figure 3.2).
    b) Computer-Assisted simulation system (CASSOS) 2001 imaging software used for the treatment of Orthognathic Surgery, which was described as a medical software approved by the main hospitals and dental cores in Hong Kong, China (Figure 3.3).

Figure 3.2 Lateral Cephalometric radiographs taken by Planmeca Promax 3D Cone-beam computed tomography machine.

A **B**



C

Figure 3.3 Computer-Assisted simulation system (CASSOS) 2001 imaging software, Hong Kong, China.

(A) Setup the software (**B**) The pointed for a landmark (**C**) Lateral cephalometric radiograph.

3.9 Data Collection

Data collection was performed according to the specific objectives.

3.9.1 Prevalence of incisor relationship among secondary school children

The incisor relationship among secondary school children was determined by a single examiner who visited in nine secondary schools out of 100 secondary schools (Yusoff, 2010) under the authority of the Kota Bharu District Education were Convenience selected. The approval from the authority of the Ministry of Education of Malaysia was obtained to allow visits to these schools (Appendix E).

The training and the calibration were done with Orthodontist (Dr. Norma) at the Orthodontic clinic in the School of Dental Sciences, Universiti Sains Malaysia, on 20 dental casts model based on incisor relationship according to British Standard Institute (BSI).

A total of 1300 participants, age group between 12 to 18 years fell in the inclusion and exclusion criteria. Each of the participants was examined at school after they filled up the consent form (Appendix B) and obtained permission from their parents. The exclusion of students includes that some students reject examination. Each of the participants was checked on the ordinary chair using disposable mouth mirrors, tongue depressors and a flashlight for facilitated direct vision by a single examiner which needs at least 1 minute of examination.

The clinical perimeter was recorded based on an incisor relationship according to British Standard Institute (BSI) by asking the subject to swallow and then bite on his or her teeth together at a centric relationship. The classification was done based on the maxillary and mandibular incisors relationship using the cingulum plateau on the

visible middle palatal surface of maxillary central incisor which was considered as a key characteristic of these classifications.

The BSI classification was classified (Ballard and Wayman, 1965) and has shown in (Figure3.4) such as:

- Class I incisor relationship is when the incisor edge of lower central incisors occludes with or lie immediately below the cingulum plateau of upper central incisors.
- Class II div 1, incisor relationship is when lower central incisor edges occlude posterior to the cingulum plateau of the upper central incisors with increased overjet and proclined upper central incisors.
- Class II div 2 incisor relationship is when lower central incisor edges occlude posterior to the cingulum plateau of the upper central incisors with minimal overjet and retroclined upper central incisors.
- Class III incisor relationship is when the incisor edge of lower central incisors lies anterior to the cingulum plateau of upper central incisors with reversed overjet or edge to edge contacts of the upper and lower incisors.

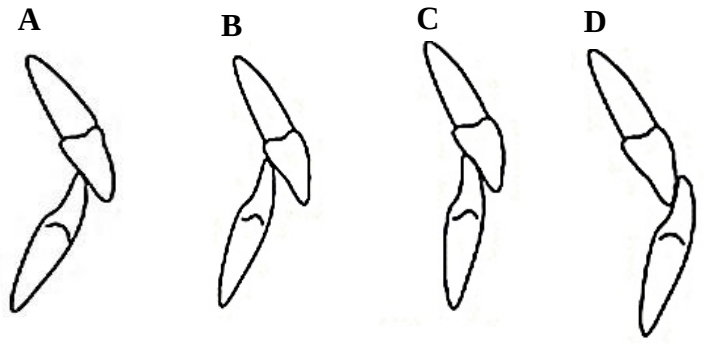


Figure 3.4 Incisor relationship (BSI).
(**A**) Class I. (**B**) Class II div 1. (**C**) Class II div 2. (**D**) Class III.

3.9.2 Craniofacial morphology among Malay group

The comparison of craniofacial morphology of Malay patients with Class I, Class II and Class III malocclusions was done among 120 Malay patients and selected randomly from the archive of the Orthodontic clinic, since 2014 to 2018 School of Dental Sciences, Hospital USM. These radiographs were selected as per the inclusion and exclusion criteria through checking 120 cast models according to Angle's classification based on molar relationship and the Lateral cephalometric radiograph was extracted accordingly. The permission was getting from Hospital Director of HUSM (Appendix D) for checking the patient folder and lateral cephalometric radiograph.

The training and the calibration were done under an Orthodontist Moreover, a manual technique was used to define the soft, hard tissue landmark, angle and linear measurements on a lateral cephalometric radiograph at the orthodontic clinic in the School of Dental Sciences, Hospital USM.

The lateral cephalometric radiographs were traced digitally and analyzed based on Jarabak, Steiner, and Tweed by a single examiner using the software for treatment Orthognathic Surgery, A Computer-Assisted simulation system (CASSOS) 2001, Hong Kong, China, which was used on lateral view for tracing as (Figure 3.5).

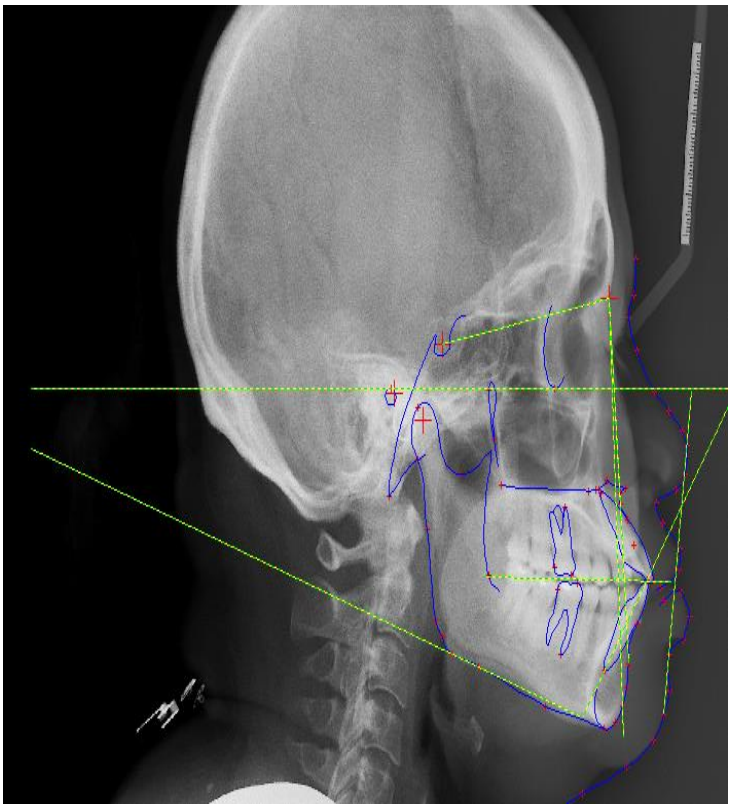


Figure 3.5 Digital tracings for lateral cephalometric radiographs by (CASSOS) software.

3.10 Measurements

3.10.1 Hard and soft tissue landmarks

The hard and soft tissue points of the lateral cephalometric radiographs were used for establishing the craniofacial morphology. These points have been defined and illustrated in (Table 3.2) and (Figure 3.6).

Table 3.3 Hard and soft tissue landmark on the lateral cephalometric radiographs (Rana *et al.*, 2017).

Hard and Soft tissue points		Description
S	Sella	the center of the sella turcica.
N	Nasion	placed at the front nasal suture.
Or	Orbitals	the most inferior point on inferior orbital margin.
ANS	Anterior nasal spine	the apex of the anterior nasal spine.
Point A	Subspinal	the most posterior point on the anterior contour of the upper alveolar process.
Is	Incisal superiors	the midpoint of the incisal edge of the most prominent upper incisor.
Ii	Incisal inferior	the midpoint of the incisal edge of the most prominent lower incisor.
Point B	Supramental	the most posterior point on the anterior contour of the lower alveolar process.
Pog	Pogonion	the most anterior point on the mandibular symphysis.
Gn	Gnathion	the most anteroinferior point on the symphysis of the chin constructed from the line drawn perpendicular to the line connecting the mention and pogonion.
Me	Mention	the most inferior point on the mandibular symphysis.
Go	Gonion	a point on the curvature of the angle of the mandible located by bisecting the angle formed by lines tangent to the posterior ramus and inferior border of the mandible.
Ar	Articulare	the point at the junction of the posterior border of the ramus and the inferior border of the cranial base.
Cd	Condylion	the most superior posterior point on the condylar head.

Hard and Soft tissue points		Description
Po	Porion	the most superior point on the external auditory meatus.
Ptm	Pterygomaxillary	the intersection between the nasal floor and the posterior contour of the maxilla.
PNS	Posterior nasal spine	the tip of the posterior nasal spine maxilla.
Ls	Labial superior	the most prominent point on the pro labium of the upper lip.
Li	Labial inferior	the most prominent point on the pro labium of the lower lip.
SPog	Soft tissue pogonion	the most prominent point on the chin.
D	Midpoint symphysis	the midpoint of the bony symphysis.

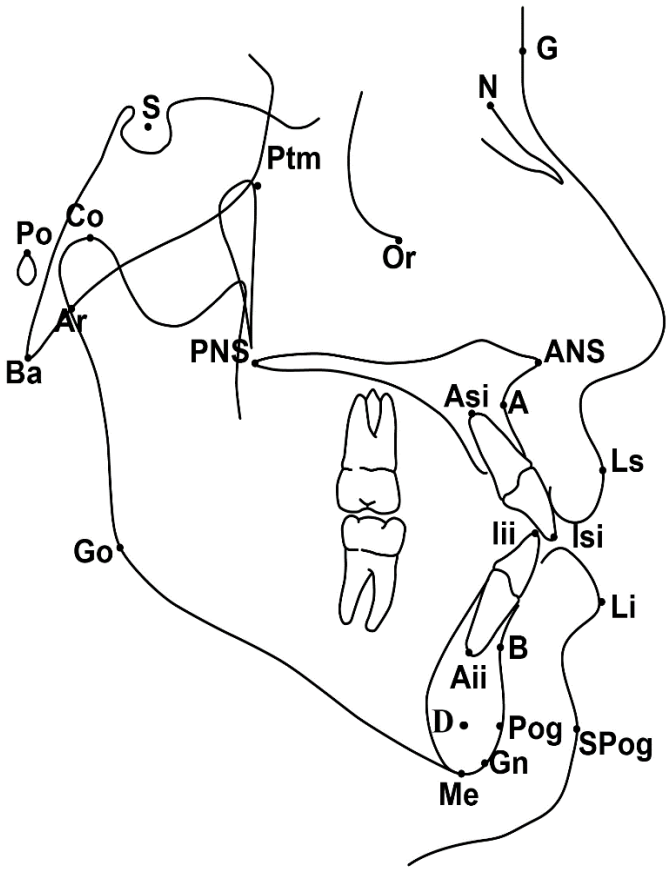


Figure 3.6 Hard and soft tissue points on the lateral cephalometric radiographs.

(S)=Sella; (N) = Nasion; (Or)=Orbital; (Po)= Porion;(Ptm)= Pterygomaxillary fissure; (Ans)=Anterior nasal spine; (Pns)= Posterior nasal spine; (Point A)= Subspinal; (Asi)= Apical superior incisor;(Isi)=Inciosr superior incisal;(Iii)= Incisor inferioir incisal; (Aii)= Apical inferior incisal; (Pint B)= Supramental; (Point D)=Midponit of the bony symphysis;(Pog)= Pogonion; (Gn)= Ganthion; (Me)=Menton; (go)=Gonion; (Ar) =Articular; (Ba)=Basion; (Co)= Condylion; (G)=Gellable;(Ls)=Labial superior; (Li)= Libial inferior; (SPog)= Soft tissue pogonion.

3.10.2 Angle and linear measurements

A total of 18 angles and 11 linear measurements were made to evaluate the significant difference in craniofacial morphology for different classes of malocclusion. These measurements have been defined in (Table 3.3, Table 3.4) and (Figure 3.7and Figure 3.8).

Table 3.4 Angle measurements on the norms value of the lateral cephalometric radiographs (Alam *et al.*, 2013; AlKhudhairi and AlKofide, 2010; Bahaa *et al.*, 2014; Li *et al.*, 2014).

Angular measurement		Description
SNA (°)	sella-nasion-point A.	angle representing maxillary protrusion in relation to the anterior cranial base.
SNB (°)	sella-nasion-point B.	angle representing mandibular protrusion in relation to the anterior cranial base.
ANB (°)	point A-nasion-point B	represents the anteroposterior discrepancy of maxillary to mandibular apical bases.
SND (°)	sella-nasion-midpoint of the bony symphysis.	which shows the growth pattern of mandible if protruded and retruded.
Go Gn to SN (°)	angle performed by mandibular plane to the anterior cranial base.	Indicated the growth of mandible if horizontal or vertical.
FMA (°)	the angle between the MP and FH plane.	Indicated the direction of lower facial growth.
IMPA (°)	the angle formed by the intersection of the MP with a line passing through the incisal edge and the apex of the the root of the mandibular incisor.	it is used as a guide in the position of the mandibular incisor related to basal bone.
FMIA (°)	the angle between the FH with a line passing through the incisal edge and the apex of the root of the mandibular incisor.	indicated the harmony and balance of the lower face and anterior limit of the dentition.
Ui to Li (°)	the angle between the long axis of the upper and the lower incisor.	represents the inclination that results from the relation between the upper and the lower incisor.

Angular measurement		Description
Li to NB (°)	the axial inclination of the lower incisors to the N-B line which indicates the angular relationship of lower incisors teeth to N-B line.	shows the anteroposterior location and angulation of the mandibular incisor relative to NB.
OP to SN (°)	the inclination of occlusal plane related to facial type.	to indicate the location of the teeth to the face and skull.
N-S-Ar (°)	the angle between sella and nasion and articular.	represents the condyle and mandibular position.
FH to N Pog (°)	the angle between FH and Nasion and pogonion.	this angle provides some indication of the horizontal position of the chin.
Ar-Go-Gn (°)	the angle between Articular and Gonion and Ganthion.	represents the growth pattern of mandibular.
Y-axis to SN (°)	the angle formed by the junction of facial length and anterior cranial base.	shows the growth pattern if vertical or horizontal.
Convexity (°)	the angle between N to point - A and Pog to point –A.	represents the convexity of the face.
S-Ar-Go (°)	the angle between sella and articular and Go.	indicated the mandibular retrognathic or prognathic
Ui to NA (°)	the angle formed by the intersection of the N-point A-line with a line passing through the incisal edge and the apex of the root of the maxillary incisor.	represents the relative location and axial inclination of maxillary incisor to point NA.

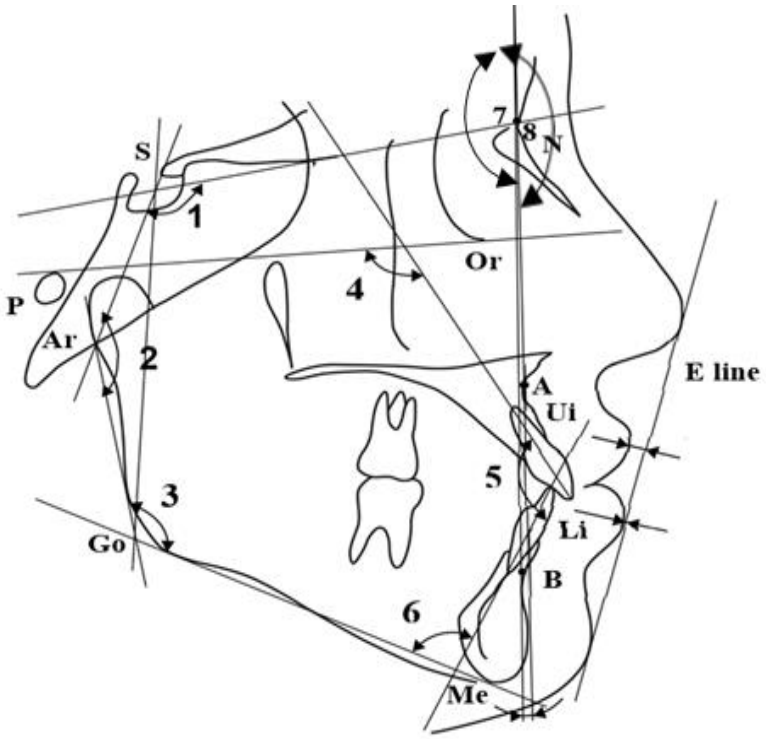


Figure 3.7 Angle measurements of the lateral cephalometric radiographs. 1=N-S-Ar; 2=S-Ar-Go ;3=Ar-Go-Me; 4= Ui to FH; 5= Ui- Li; 6=IMPA; 7= SNB; 8=ANB,

Table 3.5 Linear measurements on the norms value of the lateral cephalometric radiograph (Alam *et al.,* 2013; AlKhudhairi and AlKofide, 2010; Bahaa *et al.,* 2014; Li *et al.,* 2014).

Linear measurement		Description
S-line (mm)	the line is drawn from the lower border of Nose to the middle of the chin contour.	the line extending from the soft tissue of the chin to the middle of the lower border of the nose, this reference in determining the soft tissue balance.
E- line (mm)	aesthetic plane.	a soft tissue line peripheral from chin to the nasal tip. This line indicated soft tissue balance between the lips and the profile.
Ui-NA (mm)	the distance between the most anteriorly placed point and the NA line.	represents the proclination in the upper central incisor.
Li-NB (mm)	the distance between the most anteriorly placed point and the NB line.	represents the proclination in the lower central incisor.
S to N (mm)	the line describes the anterior of the cranial base.	to detect the length of the jaw.
S to Ar (mm)	the line defines the posterior of the cranial base.	represents the growth pattern of the jaw.
N to Go (mm)	the line describes the facial depth.	provides information about the position of the chin.
S to Pog on Y-axis (mm)	the line describes the facial length.	to assess the facial height and estimate the direction growth of the face.
S to Go(mm)	the line describes the posterior facial highest.	estimates the direction of growth.
N to Me(mm)	the line describes the anterior facial highest.	estimates path of growth.
Pog to NB (mm)	the line describes the relation between Pog to NB.	represents the position of the chin.

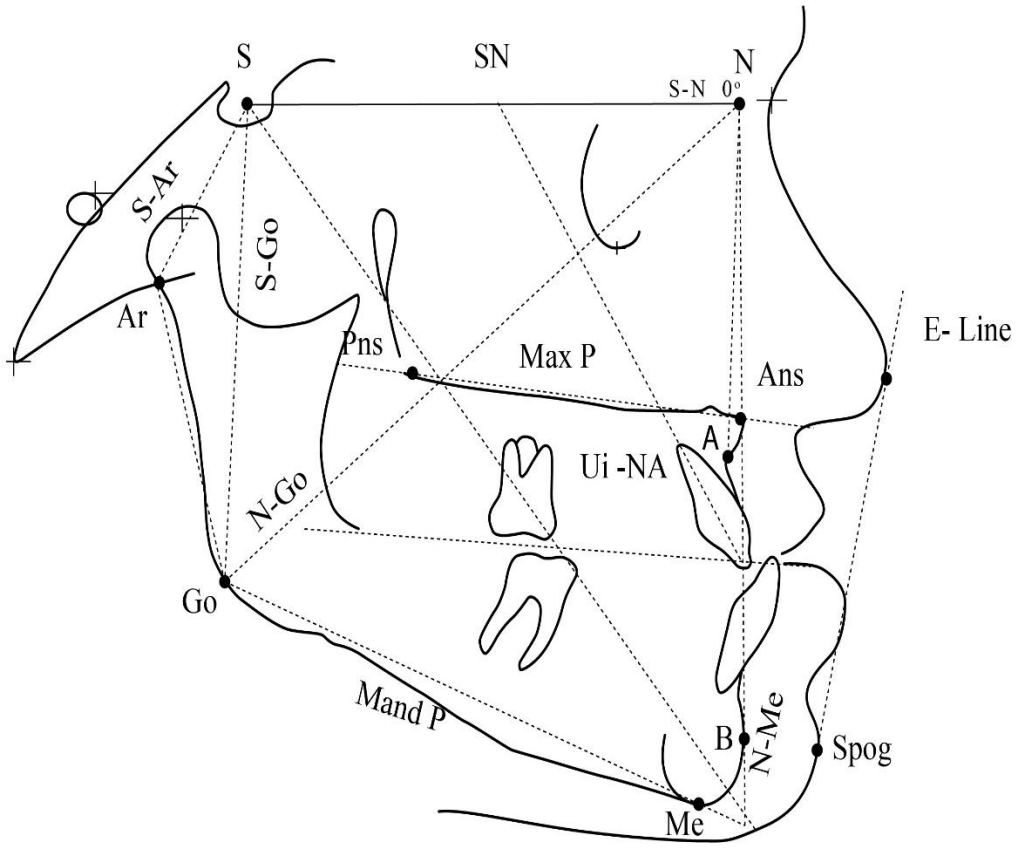


Figure 3.8 Linear measurements of the lateral cephalometric radiographs.

3.11 Reliability test

The reliability of the cephalometric measurements was determined by duplication of measurements in randomly selected subjects, twenty percent of the total sample size or 24 of the lateral cephalometric radiographs which were traced and re-analyzed two weeks after initial intra-observer analysis.

Intra-Class correlation coefficients (ICC) were shown to be 0.80 to 0.96 has shown in (Table 3.6), the coefficient values have displayed between good to excellent correlation values according to Portney LG and Watkins MP interpretation (Portney and Watkins, 2009).

Table 3.6 Interobservers study of lateral cephalogram measurement.

Measurements (°) / (mm)	ICC*
N-S-Ar(°)	0.82
S- Ar-Go(°)	0.84
Ar-Go-Me(°)	0.88
S-N(mm)	0.80
S-Ar(mm)	0.83
MP to SN(°)	0.90
Y-axis to SN(°)	0.85
SNA(°)	0.81
SNB(°)	0.84
ANB(°)	0.89
SND(°)	0.80
FH-N-Pog (°)	0.92
Convexity(°)	0.87
Go Gn to SN(°)	0.84
Op to SN(°)	0.88
FMPA(°)	0.89
S to Go(mm)	0.98
N to Me(mm)	0.94
Pog to NB(mm)	0.84
N to Go (mm)	0.82
S to Pog on Y-axis (mm)	0.85
Ui to Li(°)	0.85
Ui to NA(°)	0.81
Li to NB(°)	0.89
Li to Go Gn(°)	0.81
IMPA(°)	0.82
FMIA(°)	0.87
Ui to NA (mm)	0.88
Li to NB (mm)	0.96
S to E (mm)	0.89

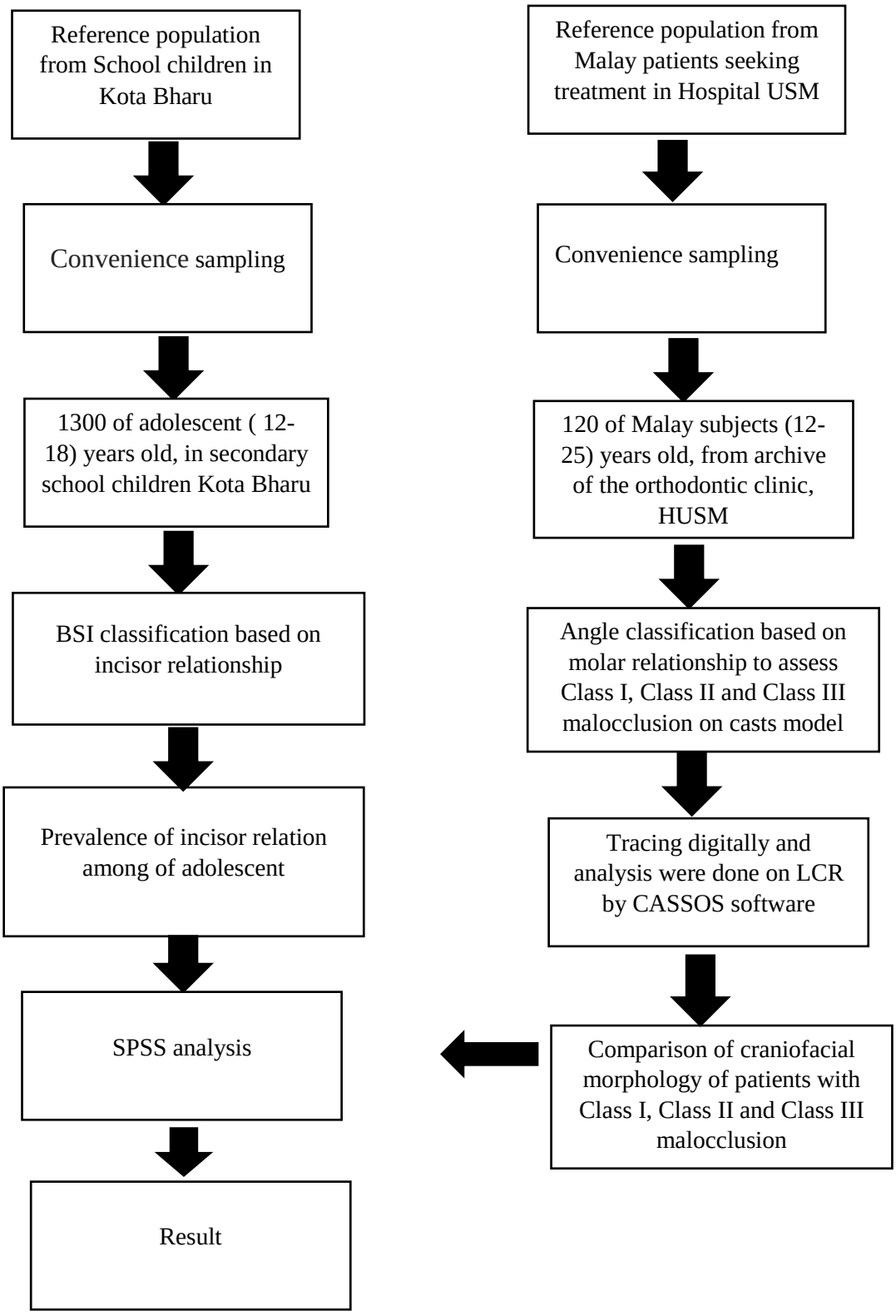
3.12 Statistical Analysis

The collected data were analyzed by (IBM, USA) software Statistical Package for the Social Sciences (SPSS) (version 24).

The descriptive statistics were used to determine the prevalence of incisor relationship among school children, for calculation and data visualization of the variables which was analyzed and distributed through the frequency, percentage at 95% of confidence interval, with calculated mean age of different types of malocclusion and the standard deviation when P-value set at $P<0.05$.

In order to compare the craniofacial morphology of different classes of malocclusion, One-way Analysis of Variance (ANOVA) and Post Hoc test by Bonferroni was used when the test of homogeneity of variance is equally assumed. The sample size was more than 30 for each class, which was deemed to be the Central Limit Theorem (Norsa'adah, 2013) when the level of significance in all statistical analyses was set at $P<0.05$.

3.13 Flow Chart



CHAPTER FOUR

RESULT

4.1 Prevalence of incisor relationship among school children

4.1.1 Profile of sample among school children

A total of 1300 samples of school children in Kota Bharu; 720 (55.4 %) females, and 580 (44.6%) males were examined and assessed for the prevalence of incisor relationship. In addition, they were also selected based on the inclusion criteria, with the mean age of 14.5 years old, with a standard deviation (SD) of (1.39). The sample was further subdivided into groups as shown in (Table 4.1).

Table 4.1 Socio-demographic characteristic.

Variable	Mean (SD)	n	%
Age(year)	14.5(1.39)		
Ethnicity			
Malay		876	67.4
Chinese		365	28.1
Indian		59	4.5
Gender			
Female		720	55.4
Male		580	44.6
Age			
12 to 14 years		724	55.7
15 to 18 years		576	44.3
Total		1300	100

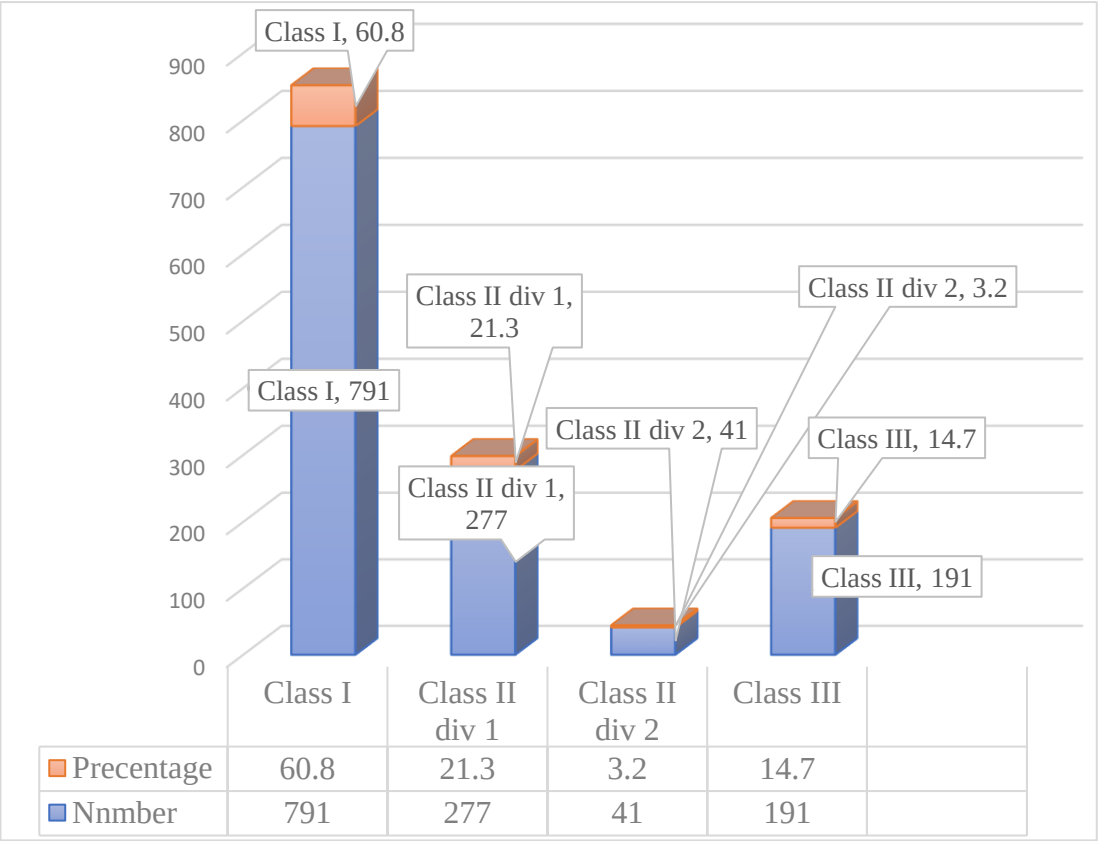
4.1.2 Prevalence of incisor relationship among school children

The distribution of prevalence of incisor relationship according to BSI Classification was 791(60.8%), 277 (21.3%), 41 (3.2%) and 191 (14.7%) for Class I, Class II div 1, Class II div 2 and Class III incisor relationship respectively as shown in (Table 4.2), (Figure 4.1).

Table 4.2 Distributions the prevalence of incisor relationship among school children**.**

Classification of incisor relationship	**n**	**%**
Class I	791	60.8
Class II div 1	277	21.3
Class II div 2	41	3.2
Class III	191	14.7
Total	1300	100

Class II div 1 = Class II division 1, Class II div 2 = Class II division 2.



Class II div 1 = Class II division 1, Class II div 2 = Class II division 2.

Figure 4.1 Distribution of the prevalence of incisor relationship according to BSI classification among school children**.**

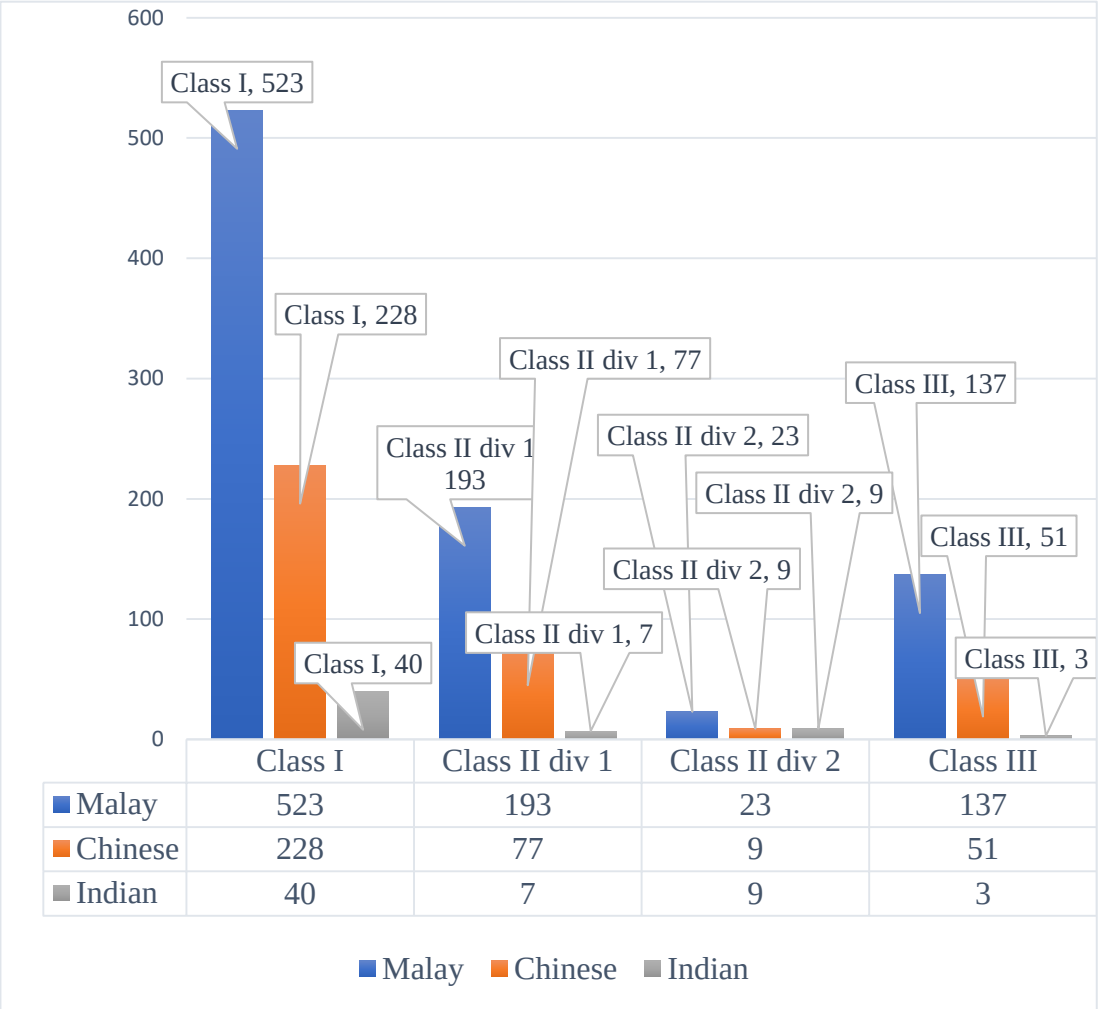
4.1.3 Distribution the prevalence of incisor relationship among ethnic group

The distribution based on ethnicity has been represented in (Table 4.3), (Figure 4.2) and showed that the Malay group has the highest percentage of prevalence of Class I incisor relationship followed by Chinese and Indian. Class II div 1, and Class II div 2 incisor relationship in Malay group was found to have a higher percentage of prevalence than the other ethnic groups. Although, the Class III incisor relationship of the Malay group has shown to have the highest prevalence when compared to Chinese and Indian groups.

Table 4.3 Distributions the prevalence of incisor relationships among ethnic groups.

Ethnicity	**n(%)**	**Class I n(%)**	**Class II div 1 n(%)**	**Class II div 2 n(%)**	**Class III n(%)**	**Total n(%)**
Malay	876(67.4)	523(66.1)	193(69.7)	23(56.1)	137(71.7)	876(100)
Chinese	365(28.1)	228(28.8)	77(27.8)	9(22)	51(26.7)	365100)
Indian	59(4.5)	40(5.1)	7(2.5)	9(22)	3(1.6)	59(100)
Total	1300(100)	791(100)	277(100)	41(100)	191(100)	1300(100)

Class II div 1 = Class II division 1, Class II div 2 = Class II division 2.



Class II div 1 = Class II division 1, Class II div 2 = Class II division 2.

Figure 4. 2 Distribution of the prevalence of incisor relationship among various ethnicity groups.

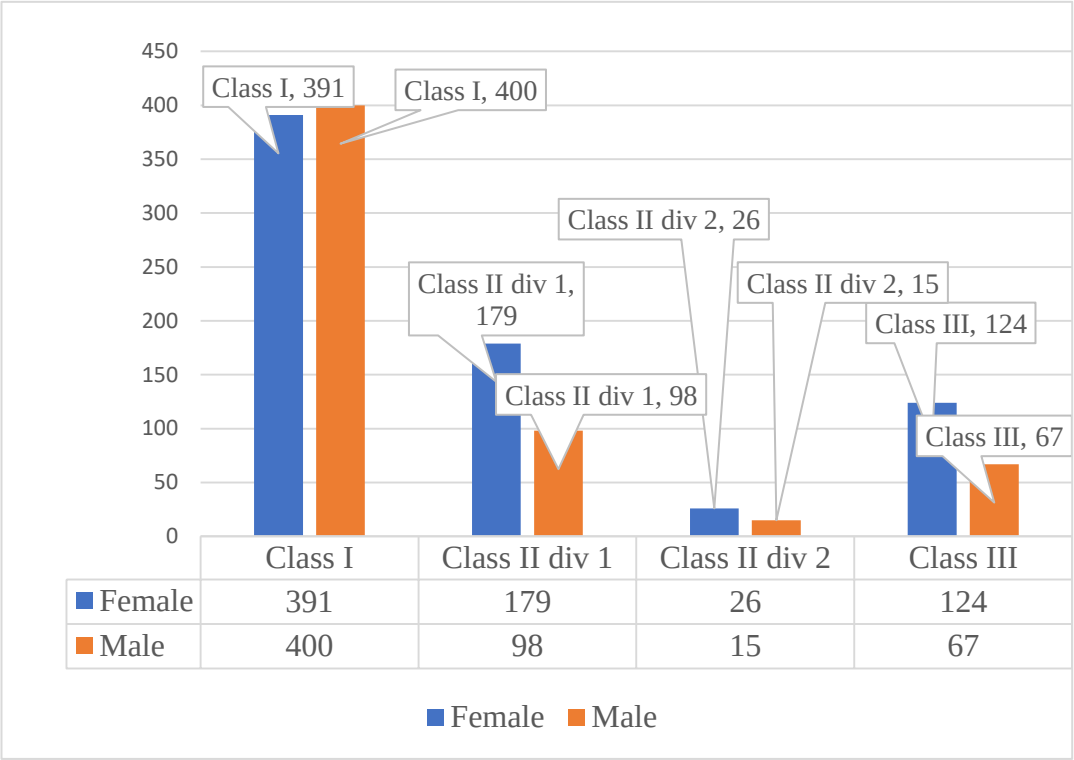
4.1.4 Distribution the prevalence of incisor relationship based on gender group

The distribution based on gender has been represented in (Table 4.4), (Figure 4.3) and showed that the prevalence of Class I incisor relationship was higher in male group than female group, however, Class II div 1, Class II div 2 and Class III incisor relationship were higher in female group than male group.

Table 4. 4 Distribution of the prevalence of incisor relationship based on the gender group.

Classification of incisor relationship	**Gender**		**Total**
	Female	**Male**	**n (%)**
	n (%)	**n (%)**	
Class I	391(49.4)	400 (50.6)	791(100)
Class II div 1	179(64.6)	98 (35.4)	277(100)
Class II div 2	26 (63.4)	15(36.6)	41(100)
Class III	124(64.9)	67(35.1)	191(100)
Total	720(55.4)	580(44.6)	1300(100)

Class II div 1 = Class II division 1, Class II div 2 = Class II division 2.



Class II div 1 = Class II division 1, Class II div 2 = Class II division 2.

Figure 4.3 Distribution of the prevalence of incisor relationship based on the gender group.

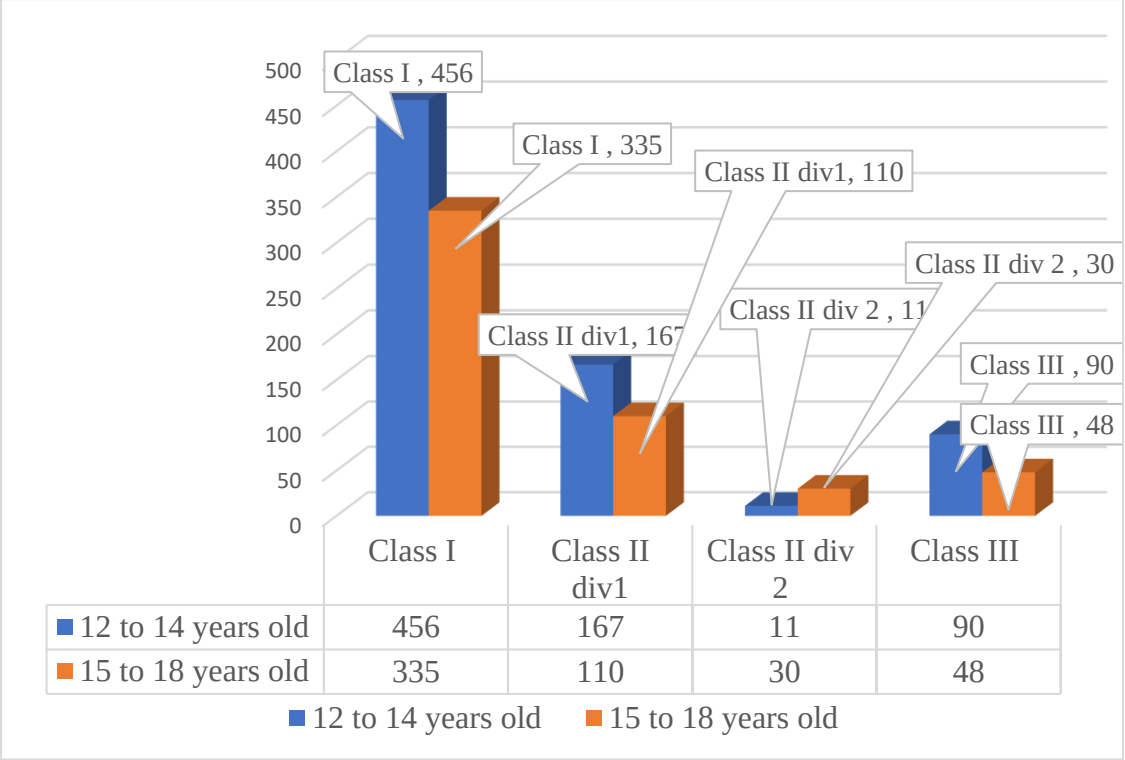
4.1.5 Distribution the prevalence of incisor relationship based on age group

The distribution based on age group has been represented in (Table 4.5) and (Figure 4.4) showed that the prevalence of Class I and Class II div 1, incisor relationship was higher in age group between 12 -14 years old than 15 - 18 years old, however, Class II div 2 and Class III malocclusion were higher in 15 - 18 years old than the 12 -14 years old group.

Table 4.5 Distribution of the prevalence of incisor relationship based on the age group.

Classification of incisor relationship	**Age**		**Total n(%)**
	12 – 14 years old n(%)	**15 -18 years old n(%)**	
Class I	456(57.6)	335(42.4)	791(100)
Class I div 1	167(60.3)	110(39.7)	277(100)
Class II div 2	11(26.8)	30(73.2)	41(100)
Class III	90(47.1)	101(52.9)	191(100)
Total	724(55.7)	576(44.3)	1300(100)

Class II div 1 = Class II division 1, Class II div 2 = Class II division 2.



Class II div 1 = Class II division 1, Class II div 2 = Class II division 2.

Figure 4.4 Distribution of the prevalence of incisor relationship based on the age group.

4.2 Craniofacial morphology among Malay group

4.2.1 Socio-demographic characteristic of Malay group

The sample comprised 120 Malay subjects (60 females and 60 males), all within the mean age of 19.1 (3.39) years as shown in (Table 4.6, Table 4.7 and Table 4.8) were presented the distributions of malocclusion among Malay group based on gender and age group.

Table 4.6 Socio-demographic characteristics of the Malay group.

Character	**Mean (SD)**	**n**	**%**
Age (year)	19.1(3.39)		
Ethnicity			
Malay		120	100
Gender			
Female		60	50
Male		60	50
Age			
12 to 17 years old		43	35.8
18 to 25 years old		77	64.2
Total		120	100

Table 4.7 Distributions of malocclusion among Malay group based on gender group.

Classification of malocclusion	Gender		Total
	Female	Male	
	n	n	
Class I	18	22	40
Class II	21	19	40
Class III	21	19	40
Total	60	60	120

Table 4.8 Distributions of malocclusion among Malay group based on the age group.

Classification of malocclusion	Age		Total
	12 to 17 years old	18 to 25 years old	
	n	n	
Class I	7	33	40
Class II	6	34	40
Class III	30	10	40
Total	43	77	120

4.2.2 Comparison of craniofacial morphology among Malay group

The different types of malocclusion were analyzed by using the various angular and linear measurements of lateral cephalometric radiographs (LCR). The summary of statistics for comparison between Class I, Class II and Class III of malocclusion displayed the mean and standard deviation which was further subdivided according to cranial base, skeletal, dental and soft tissue measurements in (Table 4.9 and 4.10).

4.2.2.1 Cranial base relationship

The comparison of the cranial base measurements among Class I, Class II and Class III malocclusion was done as shown in (Table 4.9). It is apparent that all cranial base angle and linear measurements were found to be significant differences. N-S-Ar (°) was increased in Class II, while in Class III value was reduced. S-Ar-Go (°) presented the mean of Class II as the highest value, however it still in normal range. The Ar-Go-Me (°) mean value in Class III was more when compared to Class I and Class II malocclusion. S-N (mm) and S-Ar (mm) have shown in Class III as the lowest value of mean when compared to Class I and Class II malocclusion.

4.2.2.2 Skeletal relationship

SNA (°) value was increased in Class II, while Class III was reduced and Class I set at normal range. SNB (°) has displayed in Class III as the highest value, when compared to Class I and Class II malocclusion. ANB (°) has exhibited the relationship between maxilla and mandible in Class II was increased value, when compared to Class I and Class III malocclusion. SND (°) in Class III malocclusion has the more value, when compared to the other types.

Go Gn to SN (°), FH-N-Pog (°) and MP to SN (°) in Class III as having the highest value when compared to Class I and Class II malocclusion. Y-Axis to SN (°) and Convexity (°) have displayed increase value in Class II when associated with the other types of malocclusion. N to Go (mm) and Facial Length on Y-Axis (mm) have a declined value in Class III malocclusion when compared to the other types. Anterior Facial Height N to Me (mm) and Posterior Facial Height S to Go (mm) were displayed the reduction of value in Class III malocclusion when associated with the other types.

Table 4.9 Comparison between different types of malocclusion according to the cranial base and skeletal relationships.

Variable	Class I n=40 Mean (SD)	Class II n=40 Mean (SD)	Class III n=40 Mean (SD)	F statistic (df)	P* value
Cranial Base					
N-S-Ar (°)	124.31(6.14)	126.45(2.68)	120.61(5.80)	13.31(2,117)	0.00*2,3
S-Ar-Go (°)	148.19(8.03)	150.09(8.83)	143.75(7.71)	6.28(2,117)	0.00*2,3
Ar-Go-Me (°)	124.32(4.99)	122.59(4.03)	132.17 (4.19)	71.67(2,117)	0.00*2,3
S-N (mm)	75.89(3.75)	78.93(6.42)	64.16 (10.24)	45.51(2,117)	0.00*2,3
S-Ar (mm)	43.38(5.83)	44.47(7.30)	32.31(6.14)	43.40(2,117)	0.00*2,3
Skeletal					
SNA (°)	84.66(3.15)	86.28(3.24)	81.35(2.35)	29.06(2,117)	0.00*1,2,3
SNB (°)	79.91(3.55)	78.73(4.76)	85.86(4.86)	29.69(2,117)	0.00*2,3
ANB (°)	3.80(2.68)	7.03(2.12)	- 0.47 (2.41)	103.87(2,117)	0.00*1,2,3
SND (°)	77.03(3.73)	75.30(4.80)	82.89(5.10)	30.18(2,117)	0.00*2,3
Go Gn to SN (°)	29.33(3.59)	29.09(9.31)	35.72(3.25)	15.41(2,117)	0.00*2,3
OP to SN (°)	15.98(3.88)	17.35(3.62)	12.87(5.91)	16.92(2,117)	0.00*3
FH-N-Pog (°)	80.18(3.61)	78.60(4.75)	85.96(4.95)	29.88(2,117)	0.00*2,3
MP to SN (°)	31.01(3.55)	28.66(3.55)	33.06(7.13)	7.46 (2,117)	0.00*3
Y Axis to SN (°)	67.97(3.67)	68.80(4.40)	64.34(4.71)	12.27(2,117)	0.00*2,3
Convexity (°)	13.21(6.23)	14.97(5.29)	0.15(6.40)	72.86(2,117)	0.00*2,3
FMPA (°)	23.13(2.99)	23(5.67)	18.06(4.93)	15.31(2,117)	0.00*2,3
Pog to NB (mm)	1.51 (1.90)	0.84(1.83)	2.75(1.42)	12.45(2,117)	0.00*2,3
N to Go(mm)	154.07(15.22)	153.70(18.98)	109.02(19.55)	82.63(2.177)	0.00*2,3
S to Pog -Y- axis (mm)	161.47(14.48)	156.94(19.58)	124.93(19.88)	48.11(2,117)	0.00*2,3
S to Go (mm)	104.89(12.06)	103.57(14.14)	78.12(14.45)	49.24(2.117)	0.00*2,3
N to Me (mm)	158.23(15.28)	155.86(20.37)	117.91(20.68)	57.05(2,117)	0.00*2,3

Mean = Mean difference .SD= Standard deviation. One- way ANOVA and post hoc analysis by Bonferroni test was showed which pair was significant, when *P-value < 0.05= a significantly different, therefore reject the null hypothesis. *P-value > 0.05 = no significant different, hence fail to reject the null hypothesis.

[1] Class I v Class II = a significant different.

[2] Class I v Class III = a significant different.

[3] Class II v Class III = a significant different.

4.2.2.3 Dental relationship

The comparison between dental measurements was shown in (Table 4.10). Furthermore, there were significant differences in all angles and linear of dental measurements. Ui to Li (°) was showed the increased value in Class III malocclusion when compared to Class I and Class II malocclusion. Ui to NA (°), Li -Go Gn (°), Ui to NA (mm), IMPA (°) and Li to NB (mm) were revealed that Class II has the highest value when compared to Class I and Class III malocclusion. While FMIA (°) and Li to NB (°) were showed the increased value of Class III malocclusion when compared to Class II and Class III malocclusion.

4.2.2.4 Soft tissue relationship

There was a significant difference acquired from the comparison between soft tissue measurements has shown in (Table 4.10). S to E (mm) and S to L (mm) was revealed the highest value in Class II when associated with Class I and Class III malocclusion.

Table 4.10 Comparison between different types of malocclusion according to the dental and soft tissue relationships.

Variable	Class I n=40 Mean (SD)	Class II n=40 Mean (SD)	Class III n=40 Mean (SD)	F statistic (df)	P* value
Dental					
Ui to Li (°)	130.64(2.32)	127.96(4.93)	136.44(6.26)	120.70(2,117)	0.00*1,2,3
Ui to NA (°)	21.94(1.53)	26.53(3.97)	22.16(3.81)	11.92 (2,117)	0.00*1,3
Li to NB (°)	25.19(4)	25.98(2.97)	28.93(5.19)	8.88 (2,117)	0.00*2,3
Li -Go Gn (°)	103.29(7.16)	105.20(6.23)	93.30(8.31)	30.69(2,117)	0.00*2,3
IMPA (°)	100.92(7.12)	103.12(6.15)	90.49(8.37)	34.40(2,117)	0.00*2,3
FMIA (°)	57(8.69)	55.54(7.76)	68(7.86)	28.14 (2,117)	0.00*2,3
Ui to NA (mm)	3.83(2.29)	4.93(2.55)	2.73(1.57)	10.15 (2,117)	0.00*3
Li to NB (mm)	9.09(4.34)	9.27(3.83)	5.57(2.62)	12.86 (2,117)	0.00*2,3
Soft tissue					
S to E (mm)	23.69(4.62)	24.78(5.91)	16.62(5.20)	28.19(2,117)	0.00*2,3
S to L (mm)	63.50(10.91)	59.15(11.78)	50.61(11.58)	14.53 (2,117)	0.01*2

Mean = Mean difference .SD= Standard deviation. One- way ANOVA and post hoc analysis by Bonferroni test was showed which pair was significant, when *P-value < 0.05 = a significantly different, therefore reject the null hypothesis. *P-value > 0.05 = no significant different, hence fail to reject the null hypothesis.

[1] Class I v Class II = a significant different.

[2] Class I v Class III = a significant different.

[3] Class II v Class III = a significant different.

CHAPTER FIVE

DISCUSSION

5.1 Prevalence of incisor relationship among school children

The present study was carried out among school children in Kota Bharu district, the number of secondary schools' government is 100 according to the Ministry of Education in Kota Bharu, Kelantan, Malaysia (Yusoff, 2010). It's situated in the north-eastern part of Peninsular Malaysia which serves as the state capital of Kelantan. A total of the population was 1539.601 million in this state which was divided according to the ethnic groups such as Malay 1,378,352, Chinese 48,787, Indian 3,658 and another group 8,843. A majority of the population is Kelantanese Malay which was considered as purer Malay than other states, more Islamic, more agrarian but has less Chinese and a minority of Indian residents (Ricklefs, 2009).

The diagnosis of malocclusion is an essential criterion for the achievement of any orthodontic treatment, and it is important for the orthodontist to have suitable knowledge of dental occlusion and the underlying skeletal relationship of the patient to reach the appropriate diagnosis and treatment plane of the malocclusion (Al-Hamlan *et al.*, 2015). A good procedure of recording malocclusion is critical for documentation of the prevalence and severity of malocclusion in various populations and also will help in education and categorizing different types of malocclusion (Hassan and Rahimah, 2007).

The British Standard Institute classification (BSI) was introduced by Ballard and Wayman (1965), it was considered as qualitative methods are convenient in expressing the occlusal traits for classifying the various types of dental malocclusion based on incisor relationship and including Angle's classes (Ballard and Wayman, 1965).

The incisor classification is easier and more reliable than Angle's classification, therefore, most of the patients are commonly more aware of incisor rather than buccal section relationship. Hence, its correction is a central interest of orthodontic treatment (Arvind *et al.*, 2015).

The reliability of the BSI method was deemed superior to Angle's classification because the posterior teeth did not affect and in conflict with the incisor occlusion type. The preceding validity of the Angle classification has been reported as the sagittal dental dimension but did not describe the transverse and vertical dental dimensions; moreover, there is also the absence of a reflection of the face (Du *et al.*, 1998).

There was a very inadequate data in this area, particularly for the Malaysian population. The findings from this research will add on to the pool of knowledge gathered from former researches that have been conducted in Malaysia. The overall exhibition in this study found that Class I incisor relationship was more common as 60.8%, followed by Class II div 1, 21.3%, Class III 14.7% and Class II div 2, 3.2%.

Our report has shown Class I incisor relationship as 60.8%, on the contrary, another study that has reported the distribution prevalence of Class I lower than our report. This difference might be related to different age groups as they used 7 to 17 age groups, and different sample sizes as our study have 1300 as compared to 556 (Ismail *et al.*, 2017).

Ismail et al have minor sample size which might be the reason in variation as it is not representing the normal distribution of population and determination of malocclusion done on patients cast as compared to our study we evaluate the malocclusion in normal population on the base of incisor relation in the normal population without any presenting complain. The variation of these outcomes related to the recording process

might clarify these findings by using only the study model of patients. Our finding related to the prevalence of Class I was higher than the previous study as they were using small sample size (240) as compared to us (1300), might be another reason difference in inclusion and exclusion criteria, as our group was 12 to 18 years old as compared to chu et al who used 18 to 27 age group (Chu *et al.*, 2009). In conclusion, this dissimilarity between the two studies might be related to smaller sample sizes and different age groups.

Another prior study with 700 patients attending the Orthodontics Department of Shiraz University, Medical Sciences, aged 6 to 14 years old (Oshagh *et al.*, 2010) has presented lower value in Class I than our finding. The differences between both studies were related to the different methods used for measuring occlusion abnormality and a variety of ethnic groups. There might be another reason, our study determines the prevalence of malocclusion in the normal population as compare to Oshagh et al who determines the prevalence among patients. Furthermore, our study representing the distribution of malocclusion among the normal population.

Our finding has revealed that as the lower value of Class I when compared to other preceding reports among 350 of Nepal's groups, aged between 8 to 36 years old (Sharma, 2018). The differences between both studies might be related to the method used to evaluate the malocclusion based on the molar relationship compared to our study that used incisor relationship, ethnicity differences and the broad range of age groups differences which might play important role in dissimilarities.

The distribution of prevalence of Class II div 1, incisor relationship in our report was 21.3%, on the other hand, a previous study among 142 young adult Malaysia population, in the age group of 18 to 25 years old revealed that Class II div 1, was

16.2% (Sheikh *et al.*, 2014). Which was less than our report. The differences might be related to the method used to determine the malocclusion based on the molar relationship compared to our study that used the incisor relationship.

There might be an additional explanation the ethnicity distribution has shown the Chinese group was higher proportion when compared to the Indian and Malay groups. In contrast, in our report, the Malay group has the highest proportion than Chinese and Indian. It might be concluded that dissimilarity could be related to the racial group had certain hereditary predisposition tendency to some type of malocclusion.

A prior different study among 691 school children, in the age group of 10 to 18 years old in Leh Region, India, it has shown as 8.7%, (Singh *et al.*, 2015). It was less than our report. The differences between both studies were related to the measuring process to determine malocclusion according to Angle classification based on the molar relationship was used for the previous study but our report used BSI classification based on incisor relationship. There might be other reasons related to gender distributed was showed equal distribution in Class II div 1, for the previous study, on another hand our report was showed female group has a higher distribution than the male group.

Another prior report among 339 armies of three ethnic groups Malay, Chinese and Indian, age group 17 to 22 years old (Soh *et al.*, 2005) has shown the higher value of prevalence Class II div 1,as 25.6%, when compared to our study. The dissimilarity might be related to the study design which was presented in the previous study was done in the recruitment center, but our report was done on a multicenter. There might be more explanations associated with ethnic distributions in the previous study was

showed a high percentage of Chinese group than another ethnic group, but our report was presented the Malay group has a high percentage than another ethnic group.

The distributions of the prevalence of Class II div 2 in the present report were 3.2%, it was supported by a previous study in Naples (Singh and Sharma, 2014) and Asian male study by (Soh *et al.*, 2005). However, Ismail et al were found the Class II div 2 as 7.8% among Malay, Chinese and Indian patients attending to IIUM dental clinic (Ismail *et al.*, 2017), which was displayed higher than our report. In contrast, another former study conducted by Silva and Kang among 570 of Latino group was showed the lower value of Class II div 2, as 1.2% (Silva and Kang, 2001), when compared to our report.

The differences of these findings might be related to the distributions of malocclusion for both previous studies were done on patients with presenting complain at the dental clinic but our report the distribution was representing on the normal population without any presenting complain. There might be another reason our report was done in a multicenter, while both previous studies were done at one dental clinic center and showed as different racial groups.

The current study was found Class III as 14.7%, when compared to another prior study have shown almost similar and supported by (Al-Maqtari, 2012; Chu *et al.*, 2009; Sheikh *et al.*, 2014). On the other hand, other studies were conducted by Ismail et al and Soh et al have shown high value (Ismail *et al.*, 2017; Soh *et al.*, 2005), when compared to our report. The differences of these findings might be related to ethnic group distributions, the sample size was smaller, and the age group was different in Sho et al study when compared to our report. Ismail et al were representing the

distributions of malocclusion among patients at the dental clinic but our report the distribution was done on the normal population in a multicenter place.

The increasing knowledge of aesthetics between the population has been revealed in patients seeking orthodontic assistance for correction of malocclusion. Many individual's methods an orthodontist requesting for the pleasant smile. During adolescence or permanent dentition has led children to report for a correction after the age of 12 years because it was showed higher growth potential at adolescence and difficult mechanotherapy compromises to orthodontic camouflage. This knowledge might be assisted to improve the aesthetic of patients looking for orthodontic instruction for the correction of malocclusion (Jakati *et al.*, 2017).

5.2 Craniofacial morphology among Malay group

The sample comprised of 120 cephalometric radiographs selected retrospectively on the basis of the observed molar relationship according to Angle classification and based on the criteria as required in the materials and methods. The current research revealed significant differences in craniofacial morphology between various types of malocclusion. Each of malocclusion can have a different underlying dento-skeletal shape and that shape can also reveal various ethnic variances.

The radiographic cephalometry has been used widely to study the facial structure and to develop procedures to aid in orthodontic diagnosis and treatment planning. It is also used to evaluate treatment progress and craniofacial growth, to predict growth for different patients, and for orthodontic research (Ajayi, 2005).

5.2.1 Cranial base relationship

The cranial base angle has been commonly explained to detect various types of Angle classification of malocclusion based on molar relationship (Dhopatkar *et al.*, 2002; Gong *et al.*, 2015; Hopkin *et al.*, 1968; Kasai *et al.*, 1995). Bjork (1963) was observed the total of cranial base angle (Saddle, Articulare, and Gonial angle), indicated to describe the progress on the facial outline and showed the value in Caucasians was 396° (Björk, 1963). When compared to our report was found as a similar value in Class I malocclusion.

The Saddle and Gonial angle value in our report in Class I malocclusion was supported by a previous study by Alam (2012), who stated the cephalometric norm in Bangladeshi population, age group 20 year old (Alam *et al.*, 2012). Another former study supported our finding by Ikoma and Arai (2018), a study was conducted among Japanese women with Class I malocclusion, aged 20 years old (Ikoma and Arai, 2018),

and Dhopatkar (2002), was conducted study in Caucasian patients to assess the cranial base relationship with Class I, Class II and Class III malocclusion, age group between 8 to 12 years old (Dhopatkar *et al.*, 2002). However, Kuramae (2007), was conducted the study among black Brazilian patients, age group between 10 to 14 years old, has displayed extra prognathic on maxilla with a convex shape and the mandibular plane was sharp (Kuramae *et al.*, 2007), when compared to our report. The differences between these finding might be related to method for traced and measured for the previous study was done by manual technique compare to our report was done by digital software (CASSOS) and wide range of age group in Kuramae et al. was used aged 10 to 14 years old, black Brazilian patients and our report was used age group 12 to 25 years old Malay patients.

A previous study was found that increase and reduction in cranial base angle govern the anterior and posterior place of the condyle in cranial base, with the outcome in Class II and Class III malocclusion (Alves *et al.*, 2008; Sayın and Türkkahraman, 2005), when compared to our report was found similar finding in Class II and Class III malocclusion. Although, Class II malocclusion in our report has shown the increased value in the Saddle angle, when compared to the previous study was supported our report by (Raja, 2017). While, Gonial angle in our report was showed increased value compare to another former study by Adel (2016), among Egyptian adults, age group 18 to 55 years old (Adel *et al.*, 2016). These dissimilarities might be related to the method used for tracing and measured, Power Cephalo software (ReazaNet Co., Ltd., Tokyo, Japan) was used for the previous study compare to our report was used CASSOS (Hong Kong) software and ethnic group between both studies was different.

In contrast, Class III malocclusion in our report was finding reduce value in Saddle angle and Articular angle and Gonial angle, when compared to previous study by Ishii (2002), among Japanese and Caucasians females patients, age group 19 to 20 years old (Ishii *et al.*, 2002). The dissimilarity between these findings might be related to the basis of the sample which was selected for the previous study from two different hospitals in various countries, but our report has selected all samples from the same hospital. There was might be another explanation number of the sample size was showed a small number in the previous study (53) compare to our report was (120). Moreover, the previous study was used different digital software for traced and measured the cephalometric landmark when compared to our report.

5.2.2 Skeletal relationship

This study was compared the skeletal discrepancy between various types of malocclusion, 120 of lateral cephalometric radiograph among Malay group in Kota Bharu, Malaysia, was collected to compare the anterior-posterior skeletal relationship of the jaw's relation to Nasion as presented by SNA, SNB, ANB angle.

The finding in current study showed skeletal relationship (SNA, SNB, ANB) for Class I malocclusion was consistent with that of Gu (2010), who was stated a study of craniofacial characteristics of typical Chinese and Caucasian young adults, age group 19 to 25 years old (Gu *et al.*, 2010). This present study supports evidence by the previous study was done by Alam (2013), among Bangladeshi adults, age group 18 to 24 years old (Alam *et al.*, 2013). On another hand, Bahaa (2014), was showed different values in Class I and Class III malocclusion among Malay female groups, age group 18 to 24 years old (Bahaa *et al.*, 2014), when compared to our report. The differences between both studies might be related to a method to determine malocclusion on the

study model, our report was used molar relationship according to angle classification and a previous study used incisor relationship according to BSI classification. There was might be another reason, there was a wide range of age groups, our report was used 12 to 25 years old and a previous study used 18 to 24 years old as age group. Furthermore, the gender distribution was different because our report used an equal number of males and females, but the previous study used only female groups.

In contrast, Class II malocclusion was showed a different value of skeletal relationship (SNA, SNB, ANB) when compared to another prior study by Kapadia Romina (2017), among local Gujarati population, age group 20 to 30 years old (Kapadia Romina *et al.*, 2017). The dissimilarity between both studies could be associated with the method used for trace and measuring the angle of cephalometric, which was used for the previous study the manually traced compare to our report was used digital CASSOS software for traced and measured. There was might be another reason indicated to age group and ethnic group was different between both studies.

Rana (2017), was showed also different value in (ANB) skeletal relationships among Indian and Chinese groups (Rana *et al.*, 2017), aged between 10 to 13 years old when compared to our report. The differences might be related to the type of software was used for both studies, the previous study was used Win Ceph 7 cephalometric software (Japan) for tracing and our report was used CASSOS software (Hong Kong). Furthermore, the previous study was used (Chinese group and Indian group) as a different ethnic group compares to our report was used (Malay group). However, Theisen (2013), was conducted the study among Brazilian patients, supported our finding in ANB angle for Class I, Class II and Class III malocclusion (Thiesen *et al.*, 2013).

Our outcome to detect the facial profile by Facial angle was found Class I malocclusion lower value compare to the previous study was done by Abbassy and Abushal (2015), among Egyptian female and Japanese female, aged group 18 to 35 years old (Abbassy and Abushal, 2015). The differences between both studies might be related to the method used for traced and measured different angle and linear measurements, which was used in the current study digitally method and previous study manually traced. Moreover, age distribution and gender distribution were showed differently.

In Class II malocclusion was showed Facial angle in our finding different when compared to the previous study was done among Bangladeshi people (Mohammad Khursheed Alam, 2014). The dissimilarity between two studies related to the method traced and measurement and the method used for determining malocclusion. Our report was used digitally method for traced and molar relationship for determining malocclusion, while the previous study was used incisor relationship to determine malocclusion and standard manner for tracing. In contrast, Class III malocclusion in our report has a low value of Facial angle compare to Bahaa (2014), who conducted the study among Malay females (Bahaa *et al.*, 2014).

All linear measurements in our result were displayed a significant difference between Class I, Class II and Class III malocclusion. Bjork- Jarabak analysis defined that, throughout the growth, the anterior facial height (AFH) should be almost 2.3 mm - year and the posterior facial height (PFH) should be 2.9 mm - year (Gregoret, 2003).

In our finding, PFH/AFH ratio was slightly superior to Caucasian values. While a previous report carried out among Japanese and Brazilian children, it has stated also an increased PFH/AFH ratio when associated with Caucasians (Vieira *et al.*, 2014).

These dissimilarities between the studies might be related to a different racial group, our report and Japanese study are considered under the Asian population, indicated might be a genetic tendency to certain types of malocclusion and presences of sexual dimorphism in some cephalometric measurement as PFH/AFH when compared to Caucasians group. In contrast, this current study supported evidence of anterior cranial base and posterior cranial base in Class III malocclusion by Bahaa (2014), who has conducted the study among Malay females (Bahaa *et al.*, 2014).

5.2.3 Dental relationship

The dental relationship between different measurements was showed as significant differences among various types of malocclusion in this current study. The interincisal angle in our report was showed the different value in Class I and Class II malocclusion when compared to a previous study by Al-Khateeb (2009), who has stated a study among Jordanian population, (>14 or < 14 years old) aged group (Al-Khateeb and Al-Khateeb, 2009). Another former study was conducted by Bahaa (2014), among Malay female, aged group 18 to 24 years old (Bahaa *et al.*, 2014), was showed (Interincisal angle, Ui to NA (°), Ui to NA mm, Li to NB (°) and Li to NB mm) as different value in Class I and Class III malocclusion compare to our report. The dissimilarity between these studies might be related to the method used for determining malocclusion which was used for both previous studies BSI classification based on incisor relationship, however, our report was used molar relationship according to Angle classification to determine various types of malocclusion. Moreover, there was might be another reason related to age and gender distributions because it showed different between these studies, it could be indicted to some genetic predisposition to certain types of malocclusion.

In contrast, Kapadia Romina (2017), was showed the value of Ui to NA (°), Ui to NA mm, Li to NB (°) and Li to NB mm) in Class II malocclusion among local Gujarati population, age group 20 to 30 years old (Kapadia Romina *et al.*, 2017), was different rate when compared to the current study. The difference between both studies could be related to the method used for trace and measuring the angle of cephalometric, which was used for the previous study the manually traced compare to our report was used digital CASSOS software for tracing and measured. There was might be another reason indicated to age group distributions was dissimilar which was used as 20 to 30 years old, our report used as 12 to 25 years old age group and ethnic group was showed as a different racial group between both studies.

However, in our report was displayed lower incisor teeth with relation to NB has increased in Class III malocclusion, this finding was supported by previous studies (Adel *et al.*, 2016; Lahlou *et al.*, 2009).

In detecting the facial profile of IMPA and FMIA, our report has exhibited an increased in the value of IMPA in Class II malocclusion groups, while FMIA was showed an increased value in Class III malocclusion when compared to another previous study by Adel (2016), among adult Egyptians was showed differences value between both finding (Adel *et al.*, 2016). The differences between this finding might be related to the method used for tracing and measured, Power Cephalo software (ReazaNet Co., Ltd., Tokyo, Japan) was used for the previous study compare to our report was used CASSOS (Hong Kong) software and ethnic group between both studies was different.

However, another study by Alam et al. (2013), among adult Bangladeshi, aged group 18 to 24 year-old was showed differences in IMPA and FMIA angle compare to our report (Alam *et al.*, 2013). The dissimilarity among this finding related to the method used for determining malocclusion, our report was used Angle classification based on molar relationship and previous study used incisor relationship based on BSI classification. There was might be another reason associated with the method used for tracing and measured measurements were digitally in our report, but the previous study was used manually technique.

5.2.4 Soft tissue relationship

The soft tissue profile was observed as different among the ethnic group (Miyajima *et al.*, 1996). In the previous study by Rickett (1968) was revealed the E-line relationship on the upper lip place as - 4 mm and the lower lip as - 2 mm behind a line drawn from the tip of the nose to the skin pogonion (Ricketts, 1968). In this current study was presented S to E line and S to L line was increased in Class I and Class II but decreased in Class III malocclusion.

The previous study was displayed that the Malay group had a significant difference in their upper and lower lips which was extra protrusive when compared to the Caucasian (Mohammad *et al.*, 2011). The variation between these findings could be related to genetic predisposition. These were slightly predictable a difference due to the fact that both the upper and lower incisors were revealed to be more proclined for the Malay group. This finding was supported by previous reports (Lew, 1994; Naranjilla and Rudzki-Janson, 2005).

5.3 Study Limitations

The various limitations existed in this study that might limit its application and its derivative conclusion should be used in relation to its relevant context where applicable. This study was restricted to one city, the fewer Indian ethnicity (4.5%) and small sample size which confined the generalizability of these findings to the Malaysian population. As this study focuses on Kota Bahru only, where Malay ethnicity is more common, therefore, results may not be generalized to other races and populations.

Evaluation of craniofacial morphology between different types of malocclusion was based on 2D cephalometric analysis, which is considered outdated, but there are other reliable methods available such as 3D cephalometric analysis which could not be opted because of the budget and time constraints.

CHAPTER SIX

CONCLUSION

6.1 Prevalence of incisor relationship among school children

The current study was designed to determine the prevalence of incisor relationships among 12 to 18 years old school children, Kota Bharu, Malaysia, which has shown that a high distribution of prevalence of incisor relationship as 60.8%, 21.3%, 14.7 %, and 3.2 % for Class I, Class II div 1, Class III, Class II div 2 respectively. It is concluded that Class I of the incisor relationship is the most prevalent. Quarter of the sample presented with Class II which is more than Class III incisor relationship. Moreover, the Malay sample has the highest prevalence of incisor relationship compared to Chinese and Indian. The prevalence of incisor relationship was found a high in the female group. Meanwhile, the age group between 12 to 14 years old has more prevalence of incisor relationship than 15 to18 years old group. This evidence might be applicable in oral health policy in their planning for preventive strategies.

6.2 Craniofacial morphology among Malay group

The purpose of the current study was to compare the craniofacial morphology between Class I, Class II and Class III malocclusion has shown that a clinically significant difference between Malay patient with shown a distinct craniofacial feature.

The implications of this study have shown less prognathic maxilla in Class I malocclusion compare to Class II malocclusion which was showed maxilla more forwardly, indicated to prognathic profile when the condyle in a posterior position which leads to mandible lies posteriorly position to the maxilla, and anterior cranial base and the horizontal growth pattern of the mandible and open bite.

In addition, the maxilla has shown more retruded and the mandible more forward when the mandible lies anteriorly to the maxilla and anterior cranial base which indicted to retrognathic profile and vertical growth pattern was displayed in Class III malocclusion. In Class III malocclusion was showed the facial angle increased indicated to the prognathic mandible and the Convexity angle was presented as the acute angle compared to Class I and Class II malocclusion.

The upper incisor was showed in Class II malocclusion more proinclination compared to other Class I and Class III malocclusion. Class III malocclusion has shown more proinclined in lower incisors with more chin prominence compare to other classes of malocclusion.

6.3 Recommendation

This study was found Class II div 1, and Class III was raised among these school children, Kota Bharu, Malaysia, for that an increase the educational programs on teeth irregularities and oral health must be carried out for these children. Further studies are required to clarify the findings and to provide accurate estimates of the orthodontic treatment needed for these children.

This research has deliberated the craniofacial morphology between different types of malocclusion by using lateral cephalometric radiograph (LCR), it was showed the pattern examination with an assisting instrument which may provide evidence on the cranial base length and position of the maxilla, mandible and also the position of the teeth, in relations to the anteroposterior and vertical sites as well as future growth variations. The 3D angular cephalometric analysis is recommended for use in the future for further investigation because it is an accurately reliable technique and expected to be more appropriate for the diagnosis of complex orthodontic variances compared to 2D cephalometric analysis. Our findings in this study revealed that significant differences in the craniofacial feature of the Malay group which might be considered for any orthodontic treatment in the future.

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APPENDIX A

Research Information

PREVALENCE OF INCISOR RELATIONSHIP AMONG SECONDARY SCHOOL CHILDREN IN KOTA BHARU AND COMPARISON OF CRANIOFACIAL MORPHOLOGY AMONG PATIENTS WITH CLASS I, CLASS II AND CLASS III MALOCCLUSION IN HOSPITAL USM

Name of main and co-Researcher: SAMI ALJAHMI. PROF.Dr.ROZITA HASSAN

MDC Registration No :2339

INTRODUCTION

You are invited to participate in a research study looking at voluntary screening misalignment teeth malocclusion among school children. This study is sponsored by Universiti Sains Malaysia. Before you agree to participate in this research study. It is important that you read and understand this form. This form explained the purpose, procedure, benefits of risks and discomfort.

Malocclusion occurs in most of the population, but it doesn't mean that it is a normal condition. Malocclusion represents a genetic variation that leads to affected growth and morphology. The school children were shown a high percentage of the prevalence of incisor relationship of up to 1300 subjects who participated in this study for the prevalence of incisor relationship. The comparison of craniofacial morphology of different types of malocclusions selected from the orthodontic unit up to 120 patients. This study lasts for a period of 6 months.

PURPOSE OF THE STUDY

The first aim of this study was to determine the prevalence of incisor relationships between (12 to 18 years old) school children, Kota Bharu, Malaysia. The second aim was to compare the craniofacial morphology of Class I, Class II and Class III malocclusion among (12 to 25 years old) Malay patients.

PARTICIPANTS CRITERIA

The doctor in charge of this study or a member of the study staff has discussed with you the requirements for participation in this study. It is important that you are completely truthful with the doctor and staff about your health history. You should not participate in this study if you do not meet all the qualifications.

Some of the requirements for the first objective:

- Secondary dentition from right 1st molar to left 1st molar.
- Permanent incisors teeth.
- The age groups between 12 to 18 years old selected from school children, Kota Bharu, Malaysia.

For the second objective was:

- Subjects who have Class I, Class II, and Class III malocclusions.
- Standardized lateral cephalometric radiographs.
- Full permanent dentition.
- The age group 12 to 25 years old among Malay patients selected from the archive of orthodontic unit HUSM.

You cannot participate in this study for both objectives if :

- You have oral diseases and deformities which affected the craniofacial morphology such as cleidocranial palsy, Paget disease, oral cancer, cleft lip, cleft palate or other congenital deformities.
- You have undergone previous orthodontic and orthopaedic treatment.

STUDY PROCEDURES

This procedure was done during the first visit to meeting the school children. The examiner checked the students to determine the prevalence of incisal relationship based on British standard classification.

The lateral cephalometric radiographs included in this study are to compare the craniofacial morphology of different types of malocclusion. The radiographs were obtained from the orthodontic unit for doing tracing and analysis of measurements.

RISKS

There is no risk for the patients involved in the study.

REPORTING HEALTH EXPERIENCES

If you have any injury, bad effect or any other unusual health experience during this study or any health problem either directly or indirectly related to this study please contact the following researchers at any time.

Dr.SAMI ALJAHMI / PROF.DR. ROZITA HASSAN

MDC Registration No :2339

Phone number: 0142206160 / 019988616

PARTICIPATION IN THE STUDY

The participation in this study is entirely voluntary from the school children, Kota Bharu, Malaysia. You may refuse to take part in the study or you may stop your participation in the study at any time, without any penalty or loss of benefits to which you are otherwise entitled. Your participation also may be stopped by the research team without your consent if in case you have violated the study eligibility criteria. The research team member will discuss with you if the matter arises.

POSSIBLE BENEFITS

Study procedures will be provided at no cost to you. You may receive information about your health from any physical examination to be done in this study. We hope that the outcome and information regarding this research will benefit the School of Dental Sciences in the future to determine the patient's problem and treatment planning.

QUESTIONS

If you have any question about this study or your rights, please contact:

Dr. Sami Aljahmi / Prof.Dr.Rozita Hassan.

Department of Orthodontics.

School of Dental Sciences.

USM Health Campus – Kelantan.

Contact No. 0142206160 / 019 9886161.

If you have any questions regarding the Ethical Approval or any issue/problem related to this study, please contact;

Mr. Mohd Bazlan Hafidz Mukrim

Secretary of Human Research Ethics Committee USM

Division of Research & Innovation (R&I)

USM Health Campus

Tel. No. : 09-767 2354 / 09-767 2362

Email: bazlan@usm.my or jepem@usm.my.

CONFIDENTIALITY

Your information will be kept confidential by the researchers and not be made publicly available unless disclosure is required by the law. Data obtained from this study that does not identify you individually and will be published for knowledge purposes. Your original records may be reviewed by the researcher, the Ethical Review Board (Jepem) for this study and regulatory authorities for the purpose of verifying the study procedures and/or data. Your information may be held and processed on a computer. Only research team members are authorized to access your information. By signing this consent form, you authorize the record review, information storage and data process described above.

SIGNATURES

To be entered into the study, you or a legal representative must sign and date the signature page. Kindly refer (APPENDIX A).

LAMPIRAN A

MAKLUMAT KAJIAN

PREVALEN HUBUNGAN INSISOR DALAM KALANGAN PELAJAR SEKOLAH MENENGAH DI KOTA BHARU DAN PERBANDINGAN MORFOLOGI KRANOFASIAL DI ANTARA PESAKIT KELAS I, II DAN III DI HOSPITAL USM

Nama Penyelidik:Dr. SAMI ALJAHMI,PROF. DR. ROZITA HASSAN

No. Pendaftaran MDC: 2339

PENGENALAN

Anda dipelawa untuk menyertai satu kajian penyelidikan yang melihat saringan sukarela terhadap malokulusi salahjajaran gigi dalam kalangan kanak-kanak sekolah. Kajian ini ditaja oleh Universiti Sains Malaysia. Sebelum anda bersetuju untuk menyertai kajian penyelidikan ini, adalah penting untuk anda membaca dan memahami borang ini. Borang ini akan menerangkan tujuan, prosedur, manfaat terhadap risiko dan ketidakselesaan. Malokulusi berlaku pada majoriti populasi, tetapi ini bukan bermakna ia adalah keadaan yang normal. Malokulusi dalam bentuk/mewakili variasi genetik yang menjejaskan perkembangan serta morfologi. Kanak-kanak sekolah menunjukkan peratusan yang tinggi dalam prevalens hubungan insisor sehingga 1300 subjek yang mengambil bahagian dalam penyelidikan ini yang mengkaji prevalens hubungan incisor. Perbandingan morfologi kraniofasial bagi jenis-

jenis maloklusi yang berbeza dipilih daripada unit ortodontik yang berjumlah sehingga 120 pesakit. Kajian ini berjalan selama 6 bulan.

TUJUAN KAJIAN

Tujuan pertama kajian ini adalah untuk menentukan prevalens hubungan insisor di antara kanak-kanak sekolah (12 hingga 18 tahun) di Kota Bharu, Malaysia. Tujuan kedua adalah untuk membuat perbandingan morfologi kraniofasial maloklusi Kelas I, Kelas II dan Kelas III dalam kalangan pesakit Melayu (12 hingga 25 tahun).

KELAYAKAN/KRITERIA PENYERTAAN

Doktor yang bertanggungjawab dalam kajian ini atau anggota staf kajian telah berbincang dengan anda mengenai keperluan kajian ini. Adalah penting untuk anda bersikap jujur dengan doktor dan staf mengenai sejarah kesihatan anda. Anda tidak boleh mengambil bahagian dalam kajian ini sekiranya anda tidak memenuhi semua kriteria kelayakan.

Beberapa keperluan untuk objektif pertama adalah:

- Kegigian sekunder daripada molar kanan pertama dan molar kiri pertama.
- Gigi kacip kekal.
- Kumpulan umur adalah di antara 12 hingga 18 tahun yang dipilih daripada kalangan pelajar sekolah rendah, Kota Bharu, Malaysia.

Untuk objektif kedua adalah:

- Subjek yang mempunyai maloklusi Kelas I, Kelas II, dan Kelas III.
- Radiograph sefalometrik lateral terpiawai.
- Kegigian penuh kekal.
- Kumpulan umur di antara 12 sehingga 25 tahun dalam kalangan pesakit berbangsa Melayu daripada arkib Unit Orthodontik HUSM.

Anda tidak boleh mengambil bahagian dalam kajian ini untuk kedua-dua objektif sekiranya:

- Anda mempunyai penyakit mulut dan kecacatan yang memberi kesan terhadap morfologi kraniofasial seperti palsi kleidokranial, penyakit Paget, kanser mulut, bibir celah/sumbing, lelangit rekah/sumbing atau lain-lain kecacatan kongenital.
- Anda telah terlebih dahulu menjalani rawatan ortodontik dan ortopedik.

PROSEDUR KAJIAN

Prosedur ini telah dilakukan semasa pertama kali melawat kanak-kanak sekolah. Pemeriksa akan memeriksa pelajar untuk mengenal pasti prevalens hubungan insisal berdasarkan klasifikasi piawai British. Radiograf sefalometrik lateral yang dirangkumkan/dimasukkan dalam kajian ini adalah untuk membandingkan morfologi kranofasial dari jenis malokulusi yang berbeza. Radiograf telah didapatkan dari unit ortodontik untuk dilakukan pengukuran surihan dan analisa.

RISIKO

Kajian ini tidak melibatkan sebarang risiko kepada pesakit.

MELAPORKAN PENGALAMAN KESIHATAN

Jika anda mengalami apa-apa kecederaan, kesan buruk, atau apa-apa pengalaman kesihatan yang luar biasa semasa kajian ini, sila hubungi penyelidik di bawah, pada bila-bila masa.

Dr. SAMI ALJAHMI/PROF. DR. ROZITA HASSAN

Nombor Pendaftaran MDC: 2339

No. Tel.: 0142206160/0199886161

PENYERTAAN DALAM KAJIAN

Penyertaan anda dalam kajian ini adalah secara sukarela. Anda boleh menolak penyertaan dalam kajian ini atau anda boleh menamatkan penyertaan anda dalam kajian ini pada bila-bila masa, tanpa sebarang hukuman atau kehilangan sebarang manfaat yang sepatutnya diperolehi oleh anda. Penyertaan anda mungkin juga diberhentikan oleh doktor kajian atau pihak penaja tanpa persetujuan anda jika berkemungkinan anda melanggar kriteria kelayakan kajian. Ahli pasukan kajian akan membincangkan perkara ini dengan anda jika hal ini timbul.

MANFAAT YANG MUNGKIN

Prosedur kajian yang diberi tidak melibatkan apa-apa kos daripada anda. Anda mungkin menerima maklumat tentang kesihatan anda dari apa-apa pemeriksaan fizikal yang bakal dilakukan dalam kajian ini. Kami berharap hasil dan maklumat mengenai kajian ini akan memberi manfaat kepada pusat pengajian sains pergigian untuk menentukan masalah pesakit dan perancangan rawatan pada masa hadapan.

SOALAN

Sekiranya anda mempunyai sebarang soalan mengenai prosedur kajian ini atau hak-hak anda, sila hubungi.

Dr. Sami Aljahmi

Prof. Dr. Rozita Hassan

Jabatan Ortodontik, Pusat Pengajian Sains Pergigian,

USM Kampus Kesihatan.

Tel: 0142206160 / 0199886161

Sekiranya anda mempunyai sebarang soalan berkaitan kelulusan Etika kajian ini, sila hubungi:

En. Mohd. Bazlan Hafidz Mukrim

Setiausaha JK Etika Penyelidikan Manusia USM

Bahagian Inovasi dan Penyelidikan

USM Kampus Kesihatan

Tel. 09-7672354 /09-7672362

Emel: bazlan@usm.my atau jepem@usm.my

KERAHSIAAN

Maklumat perubatan anda akan dirahsiakan oleh penyelidik dan tidak akan dedahkan secara umum melainkan jika ia dikehendaki oleh undang-undang.

Data yang perolehi dari kajian yang tidak mengenal pasti anda secara perseorangan dan akan diterbitkan bagi tujuan pengetahuan.

Rekod perubatan anda yang asal mungkin akan dilihat oleh penyelidik, Lembaga Etika kajian ini dan pihak berkuasa regulatori untuk tujuan pengesahan prosedur dan/atau data kajian klinikal. Maklumat perubatan anda mungkin akan disimpan dalam komputer dan diproses dengannya. Hanya ahli pasukan penyelidik dibenarkan untuk mengakses maklumat anda.

Dengan menandatangani borang persetujuan ini, anda membenarkan penelitian rekod, penyimpanan maklumat dan pemindahan data seperti yang dihuraikan di atas.

TANDATANGAN

Untuk dimasukkan ke dalam kajian ini, anda atau wakil sah anda mesti menandatangani serta menarikhkan halaman tandatangan (lihat LAMPIRAN A).

APPENDIX B

SUBJECT INFORMATION AND CONSENT FORM
(SIGNATURE PAGE)

PREVALENCE OF INCISOR RELATIONSHIP AMONG SECONDARY SCHOOL CHILDREN IN KOTA BHARU AND COMPARISON OF CRANIOFACIAL MORPHOLOGY AMONG PATIENTS WITH CLASS I, CLASS II AND CLASS III MALOCCLUSION IN HOSPITAL USM

Researcher's Name: Dr. SAMI ALJAHMI. Prof. Dr. ROZITA HASSAN.

To become part of this study, you or your legal representative must sign this page. By signing this page, I am confirming the following:

- I have read all of the information in this Patient Information and Consent Form including any information regarding the risk in this study and I have had time to think about it.
- All of my questions have been answered to my satisfaction.
- I voluntarily agree to be part of this research study, to follow the study procedures, and to provide necessary information to the doctor, nurses, or other staff members, as requested.
- I may freely choose to stop being a part of this study at any time.
- I have received a copy of this Participant Information and Consent Form to keep for myself.

_____

Participant Name

_____

Participant I.C No

_____ _____

Signature of Participant or Legal Representative Date (dd/MM/yy)

_____

Name of Individual

Conducting Consent Discussion

_____ _____

Signature of Individual Date (dd/MM/yy)

Conducting Consent Discussion

_____ _____

Name & Signature of Witness Date (dd/MM/yy)

<u>Note:</u> i) All participants who are involved in this study will not be covered by insurance.

LAMPIRAN B

Maklumat Subjek Dan Borang Keizinan Pesakit (Halaman)

PREVALEN HUBUNGAN INSISOR DALAM KALANGAN PELAJAR SEKOLAH MENENGAH DI KOTA BHARU DAN PERBANDINGAN MORFOLOGI KRANOFASIAL DI ANTARA PESAKIT KELAS I, II DAN III DI KOTA BHARU DI HOSPITAL USM

Nama Penyelidik**:** Dr. SAMI ALJAHMI . PROF. Dr. ROZITA HASSAN

Untuk menyertai kajian ini, anda atau wakil sah anda mesti menandatangani mukasurat ini. Dengan menandatangani mukasurat ini, saya mengesahkan yang berikut:

- Saya telah membaca semua maklumat dalam Borang Maklumat dan Keizinan Pesakit ini termasuk apa-apa maklumat berkaitan risiko yang ada dalam kajian dan saya telahpun diberi masa yang mencukupi untuk mempertimbangkan maklumat tersebut.
- Semua soalan-soalan saya telah dijawab dengan memuaskan
- Saya, secara sukarela, bersetuju menyertai kajian penyelidikan ini, mematuhi segala prosedur kajian dan memberi maklumat yang diperlukan kepada doktor, para jururawat dan juga kakitangan lain yang berkaitan apabila diminta.
- Saya boleh menamatkan penyertaan saya dalam kajian ini pada bila-bila masa.
- Saya telah pun menerima satu salinan Borang Maklumat dan Keizinan Pesakit untuk simpanan peribadi saya.

Nama Pesakit/Peserta

No. Kad Pengenalan Pesakit/Peserta

Tandatangan Pesakit/Peserta atau Wakil Sah

Tarikh (ddMMyy)

Nama Individu yang Mengendalikan Perbincangan Keizinan

Tandatangan Individu yang Mengendalikan Perbincangan Keizinan

Tarikh (ddMMyy)

Nama Saksi dan Tanda Tangan

Tarikh (ddMMyy)

<u>Nota:</u> Semua peserta yang mengambil bahagian dalam kajian ini tidak dilindungi insurans.

APPENDIX C

Ethical Approval Letter

Jawatankuasa Etika
Penyelidikan Manusia USM (JEPeM)
Human Research Ethics Committee USM (HREC)

Universiti Sains Malaysia
Kampus Kesihatan,
16150 Kubang Kerian, Kelantan, Malaysia
T : (6)09-767 3000/2354/2362
F : (6)09-767 2351
E : jepem@usm.my
L : www.jepem.kk.usm.my
www.usm.my

29th April 2018

Dr. Sami Aljahmi
School of Dental Sciences
Universiti Sains Malaysia
16150 Kubang Kerian, Kelantan.

JEPeM Code : USM/JEPeM/17120693
Protocol Title : Prevalence of Malocclusion among School Children and Comparison of Craniofacial Morphology of Class I, Class II and Class III Malocclusion in Kota Bharu Population.

Dear Dr.,

We wish to inform you that your study protocol has been reviewed and is hereby granted approval for implementation by the Jawatankuasa Etika Penyelidikan Manusia Universiti Sains Malaysia (JEPeM-USM). Your study has been assigned study protocol code **USM/JEPeM/17120693**, which should be used for all communication to the JEPeM-USM related to this study. This ethical clearance is valid from **29th April 2018** until **28th April 2019.**

Study Site: Kota Bharu, Kelantan.

The following researchers also involve in this study:
1. Prof. Dr. Rozita Hassan
2. Dr. Asilah Yusof
3. Dr. Mohd Fadhli Khamis

The following documents have been approved for use in the study.
1. Research Proposal

In addition to the abovementioned documents, the following technical document was included in the review on which this approval was based:
1. Patient Information Sheet and Consent Form (English version)
2. Patient Information Sheet and Consent Form (Malay version)

Attached document is the list of members of JEPeM-USM present during the full board meeting reviewing your protocol.

While the study is in progress, we request you to submit to us the following documents:
1. Application for renewal of ethical approval 60 days before the expiration date of this approval through submission of **JEPeM-USM FORM 3(B) 2017: Continuing Review Application Form.** Subsequently this need to be done yearly as long as the research goes on.
2. Any changes in the protocol, especially those that may adversely affect the safety of the participants during the conduct of the trial including changes in personnel, must be submitted or reported using **JEPeM-USM FORM 3(A) 2017: Study Protocol Amendment Submission Form.**
3. Revisions in the informed consent form using the **JEPeM-USM FORM 3(A) 2017: Study Protocol Amendment Submission Form.**
4. Reports of adverse events including from other study sites (national, international) using the **JEPeM-USM FORM 3(G) 2017: Adverse Events Report.**
5. Notice of early termination of the study and reasons for such using **JEPeM-USM FORM 3(E) 2017.**
6. Any event which may have ethical significance.
7. Any information which is needed by the JEPeM-USM to do ongoing review.
8. Notice of time of completion of the study using **JEPeM-USM FORM 3(C) 2017: Final Report Form.**

Please note that forms may be downloaded from the JEPeM-USM website: **www.jepem.kk.usm.my**

Jawatankuasa Etika Penyelidikan (Manusia), JEPeM-USM is in compliance with the Declaration of Helsinki, International Conference on Harmonization (ICH) Guidelines, Good Clinical Practice (GCP) Standards, Council for International Organizations of Medical Sciences (CIOMS) Guidelines, World Health Organization (WHO) Standards and Operational Guidance for Ethics Review of Health-Related Research and Surveying and Evaluating Ethical Review Practices, EC/IRB Standard Operating Procedures (SOPs), and Local Regulations and Standards in Ethical Review.

Thank you.

"ENSURING A SUSTAINABLE TOMORROW"

Very truly yours,

PROF. DR. HANS AMIN VAN ROSTENBERGHE
Chairperson
Jawatankuasa Etika Penyelidikan (Manusia) JEPeM
Universiti Sains Malaysia

CERTIFIED BY: National Pharmaceutical Regulatory Agency (NPRA) | Forum for Ethical Review Committees in Asia & Western Pacific Region

Date of meeting : 13th March 2018
Venue : Meeting Room, Division of Research & Innovation, USM Kampus Kesihatan.
Time : 9.00 a.m – 2.00 p.m
Meeting No : 383

Members of Committee of the Jawatankuasa Etika Penyelidikan (Manusia), JEPeM Universiti Sains Malaysia who reviewed the protocol/documents are as follows:

Member (Title and Name)	Occupation (Designation)	Male/ Female (M/F)	Tick (✓) if present when above items, were reviewed
Chairperson: Professor Dr. Hans Amin Van Rostenberghe	Chairperson of Jawatankuasa Etika Penyelidikan (Manusia), JEPeM USM	M	✓ (Chairperson)
Deputy Chairperson: Professor Dr. Narazah Mohd Yusoff	Deputy Chairperson of Jawatankuasa Etika Penyelidikan (Manusia), JEPeM USM	F	✓ (Deputy Chairperson)
Deputy Chairperson: Associate Professor Dr. Azlan Husin	Deputy Chairperson of Jawatankuasa Etika Penyelidikan (Manusia), JEPeM USM	M	✓ (Deputy Chairperson)
Secretary: Mr. Mohd Bazlan Hafidz Mukrim	Science Officer	M	✓
Members :			
1. Associate Professor Dr. Hamid Jan Jan Mohamed	Lecturer, School of Health Sciences	M	✓
2. Tuan Haji Ismail Hassan	Community Representative	M	✓
3. Professor Dr. Nik Hazlina Nik Hussain	Lecturer, School of Medical Sciences	F	✓
4. Professor Dr. Nor Hayati Othman	Lecturer, School of Medical Sciences	F	✓
5. Associate Professor Oleksandr Krasilshchikov	Lecturer, School of Health Sciences	M	✓
6. Assoc. Prof. Dr. Sarimah Abdullah	Lecturer, School of Medical Sciences	F	✓
7. Dr. Soon Lean Keng	Lecturer, School of Health Sciences	F	✓
8. Mrs. Zawiah Abu Bakar	Community Representative	F	✓

Jawatankuasa Etika Penyelidikan (Manusia), JEPeM-USM is in compliance with the Declaration of Helsinki, International Conference on Harmonization (ICH) Guidelines, Good Clinical Practice (GCP) Standards, Council for International Organizations of Medical Sciences (CIOMS) Guidelines, World Health Organization (WHO) Standards and Operational Guidance for Ethics Review of Health-Related Research and Surveying and Evaluating Ethical Review Practices, EC/IRB Standard Operating Procedures (SOPs), and Local Regulations and Standards in Ethical Review.

PROFESSOR DR. HANS AMIN VAN ROSTENBERGHE
Chairperson
Jawatankuasa Etika Penyelidikan (Manusia), JEPeM
Universiti Sains Malaysia

CERTIFIED BY: National Pharmaceutical Regulatory Agency (NPRA) | Forum for Ethical Review Committees in Asia & Western Pacific Region

APPENDIX D

Approval Letter from Hospital Director of Hospital USM

89-1

DITERIMA
22 JUL 2018
Pejabat Pengarah
HUSM

To.
The Director
Hospital Universiti Sains Malaysia
Kubang Kerian, Kota Bharu-16150
Kelantan

Date: 22/July/2018

Sub: Application for access to Patient Records from Orthodontic Unit, PPSG, USM

Respected Sir,

I am Dr. Sami Aljahmi, MSc. Dentistry Student from orthodontic unit in PPSG and Matric number: under the supervision of Prof Dr. Rozita Hassan. Regrading my study "Prevalence of malocclusion and comparison the craniofacial morphology of different type of malocclusion in Kota Bharu population" I would like to check radiograph from archive of Orthodontic Unit to do measurement with Lateral cephalometric radiographs followed by analysis of the same. It will help me to achieve my objective for my Master degree. Hence, I kindly request you to grant me permission to get access to patient records from the archival. I hope my request will be fulfilled.

Thanking you sir

Your's Sincerely

Dr. Sami Aljahmi

Sami
0142206160

Ok
Proceed with
ethical approval

22/7/18
PROF. DR MK HISAMUDDIN NIK AB. RAHMAN
No. MPM: 32959
Timbalan Pengarah (Infrastruktur & Aset)
Hospital Universiti Sains Malaysia
16150 Kubang Kerian, Kelantan.

APPENDIX E

Approval Letter from the Ministry of Education

KEMENTERIAN PENDIDIKAN MALAYSIA
MINISTRY OF EDUCATION MALAYSIA
BAHAGIAN PERANCANGAN DAN PENYELIDIKAN DASAR PENDIDIKAN
EDUCATIONAL PLANNING AND RESEARCH DIVISION
ARAS 1-4, BLOK E8
KOMPLEKS KERAJAAN PARCEL E
PUSAT PENTADBIRAN KERAJAAN PERSEKUTUAN
62604 PUTRAJAYA

Telefon : 03-8884 6500
Faks : 03-8884 6439
Laman Web : www.moe.gov.my

KEMENTERIAN PENDIDIKAN MALAYSIA

Ruj. Kami : KPMSP.600-3/2/3JLD 30(84)
Tarikh : 16 Oktober 2017

Rozita Hassan
K.P. 690808035400

Pusat Pengajian Sains Pergigian
Universiti Sains Malaysia
16150 Kubang Kerian
Kelantan

Tuan,

KELULUSAN BERSYARAT UNTUK MENJALANKAN KAJIAN: COMPARISON OF CRANIOFACIAL MORPHOLOGY IN LATE ADOLESCENT CLASS III MALOCCLUSION APPLIANCES : A RANDOMIZED CLINICAL TRIAL

Perkara di atas adalah dirujuk.

2. Sukacita dimaklumkan bahawa permohonan tuan untuk menjalankan kajian seperti tersebut di atas telah diluluskan dengan syarat:

   i. Penyelidik perlu mendapatkan kebenaran daripada ibu bapa / penjaga murid yang terlibat dalam kajian ini.

3. Kelulusan ini adalah berdasarkan kepada kertas cadangan penyelidikan dan instrumen kajian yang dikemukakan oleh tuan kepada Bahagian ini. Walau bagaimanapun kelulusan ini bergantung kepada kebenaran Jabatan Pendidikan Negeri dan Pengetua / Guru Besar yang berkenaan.

4. Surat kelulusan ini sah digunakan bermula dari **17 Oktober 2017** hingga **17 April 2018.**

5. Tuan juga mesti menyerahkan senaskhah laporan akhir kajian dalam bentuk *hardcopy* bersama salinan *softcopy* berformat Pdf. di dalam CD kepada Bahagian ini. Tuan diingatkan supaya mendapat kebenaran terlebih dahulu daripada Bahagian ini sekiranya sebahagian atau sepenuhnya dapatan kajian tersebut hendak dibentangkan di mana-mana forum, seminar atau diumumkan kepada media massa.

Sekian untuk makluman dan tindakan tuan selanjutnya. Terima kasih.

"BERKHIDMAT UNTUK NEGARA"

Saya yang menurut perintah,

(Dr. ROSLI BIN ISMAIL)
Ketua Sektor
Sektor Penyelidikan dan Penilaian
b.p. Pengarah
Bahagian Perancangan dan Penyelidikan Dasar Pendidikan
Kementerian Pendidikan Malaysia

QUALITY SYSTEM SIRIM STANDARDS

CERTIFIED TO ISO 9001:2008
CERT. NO: AR 3166

APPENDIX F

Certificate for Oral Presentation

INTERNATIONAL ASSOCIATION FOR DENTAL RESEARCH
MALAYSIAN SECTION
(SOUTH~EAST ASIAN DIVISION)

CERTIFICATE OF PARTICIPATION

This certifies that

DR. SAMI KHALIFA SALEM ALJAHMI

has participated in the

Oral Presentation (3-minute Pitching)

in the

17th Annual Scientific Meeting of IADR Malaysian Section

held at

Holiday Villa Subang, Selangor on the 24th February 2018

PROF. DR. RAHIMAH ABDUL KADIR
President
IADR Malaysian Section

APPENDIX G

Manuscript Submission

20/12/2019

Dear Dr., Aljahmi

A manuscript has been submitted to International Medical Journal by Sami Aljahmi titled Craniofacial morphology of Class I, Class II and Class III malocclusion among Malay patients in Hospital USM which has been accepted for publication.

Title of your paper: Craniofacial Morphology with Class I, Class II and Class III Malocclusions among Malay Population in Hospital USM.
Paper reception number: GS-#6901001
According to peer referee's examination result, this paper is worth printing in the International Medical Journal. Therefore, this paper has been accepted for publication in the IMJ by an editor-in-chief of the IMJ, Prof. Tsutomu Sakuta. This is, at present, roughly supposed to appear in vol. 27 no. 6 (December, 2020).

And 16/4/2020

Dear Dr., Aljahmi

Your manuscript entitled "Comparison of craniofacial morphology of Class I and Class III malocclusion among Malay patients" has been successfully submitted online and is presently being given full consideration for publication in International Journal Psychosocial Rehabilitation.

And

20/4/2020

Dear Dr., Aljahmi,

Your manuscript entitled Prevalence of Incisor relationship among schoolchildren in Kota Bharu, Malaysia has been successfully submitted online and is presently being given full consideration for publication in International Journal Psychosocial Rehabilitation.

APPENDIX H

Turnitin Report

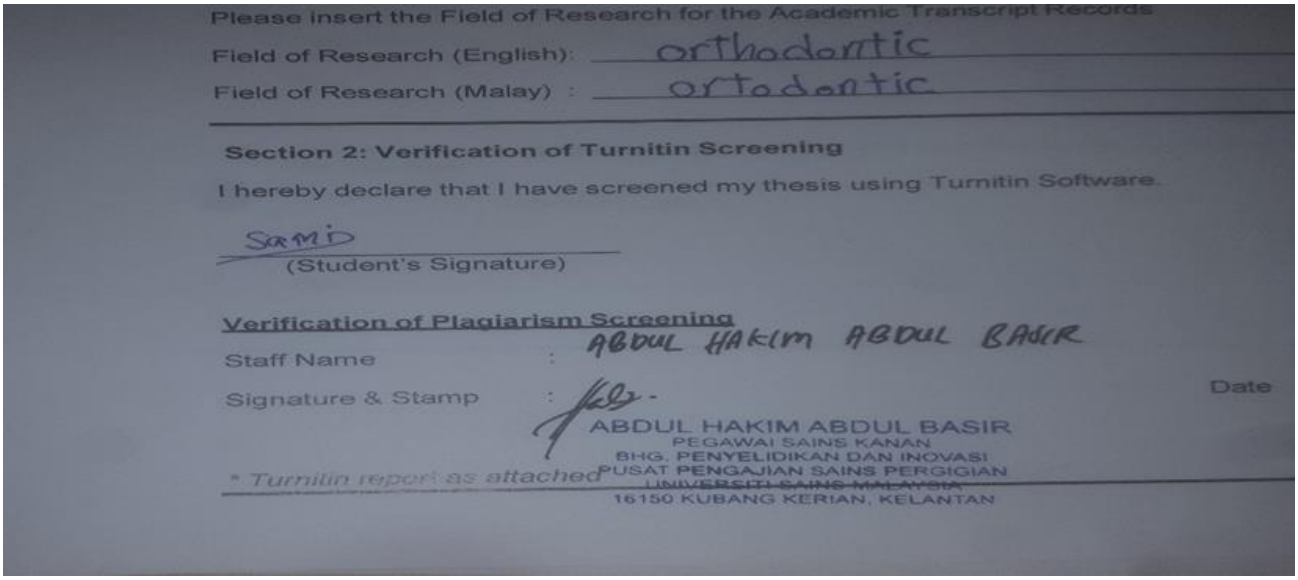
PREVALENCE OF INCISOR RELATIONSHIP AMONG SECONDARY SCHOOL CHILDREN IN KOTA BHARU AND COMPARISON OF CRANIOFACIAL MORPHOLOGY AMONG PATIENTS WITH CLASS I, CLASS II AND CLASS III MALOCCLUSION IN HOSPITAL

ORIGINALITY REPORT

28%	18%	15%	18%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Submitted to Universiti Sains Malaysia Student Paper	2%
2	dental.usm.my Internet Source	2%
3	www.ukm.edu.my Internet Source	2%
4	Submitted to Universiti Teknologi MARA Student Paper	1%
5	academicjournals.org Internet Source	1%
6	ispcd.org Internet Source	1%
7	www.ncbi.nlm.nih.gov Internet Source	1%



Please insert the Field of Research for the Academic Transcript Records

Field of Research (English): orthodontic

Field of Research (Malay) : ortodontic

Section 2: Verification of Turnitin Screening

I hereby declare that I have screened my thesis using Turnitin Software.

SAMID

(Student's Signature)

Verification of Plagiarism Screening

Staff Name : ABDUL HAKIM ABDUL BASIR

Signature & Stamp : Date

ABDUL HAKIM ABDUL BASIR
PEGAWAI SAINS KANAN
BHG. PENYELIDIKAN DAN INOVASI
PUSAT PENGAJIAN SAINS PERGIGIAN
UNIVERSITI SAINS MALAYSIA
16150 KUBANG KERIAN, KELANTAN

* Turnitin report as attached