FACIAL AND DENTAL ARCH FEATURES IN MALAY SCHOOL CHILDREN: A GEOMETRIC MORPHOMETRIC ANALYSIS

By

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ABSTRAK

SIFAT MUKA DAN RAHANG GIGI DIKALANGAN KANAK-KANAK SEKOLAH BERBANGSA MELAYU: A GEOMETRIK MORFOMETRIK ANALYSIS

ABSTRAK

Hubungkait antara maloklusi dengan tisu lembut muka masih menjadi kontroversi dan belum di fahami dengan sepenuhnya. Kajian keatas tisu lembut muka sebelum rawatan ortodontik dapat memberi gambaran penyebab kepada maloklusi Sehubungan itu, kajian ini telah dijalankan bertujuan untuk melihat hubungkait diantara ciri-ciri tisu muka lembut dengan rahang gigi di kalangan pelajar-pelajar Melayu. Secara spesifiknya, kajian ini adalah untuk mengenalpasti dan membezakan mengikut Kelas I dan Kelas II tisu muka lembut dengan ciri-ciri rahang gigi dengan menggunakan analisis *finite-element.* Selepas mendapat kebenaran daripada ibu bapa pelajar-pelajar sekolah berbangsa Melayu di Kota Bharu, Kelantan telah ditapis mengikut oklusi mereka. Terdapat 50 orang kanak-kanak yang mempunyai min umur 15±0.7 tahun telah dibahagikan kepada dua kumpulan. Kumpulan pertama telah dikelaskan mengikut oklusi Kelas I . manakala, bagi kumpulan kedua telah dikelaskan mengikut oklusi Kelas II yang tidak seimbang. Unit 3dMD stereophtogrammetry telah digunakan untuk mengambil gambar tiga dimensi tisu muka lembut mengikut piawai protokol. Seterusnya, impresi pergigian dan model kajian pergigian di kalangan kanak-kanak telah disediakan. Hasil kajian mencadangkan ciri-ciri Kelas I dan Kelas II tisu muka lembut mempunyai signifikan yang signifikan ($p<0.05$). Di samping itu, ciri-ciri Kelas I dan Kelas II bagi rahang gigi bawah turut mempunyai perbezaan yang signifikan ($p<0.05$). Kesimpulannya, terdapat perbezaan di antara rahang gigi dan hubungkait morfologikal antara Kelas I dan Kelas II bagi tisu lembut muka dan ciri-ciri rahang gigi yang dikenalpasti melalui analisis *finite-element* adalah sangat signifikan. Manakala bagi analisis *canonical correlation* menunjukkan wujudnya hubungan yang sangat rapat bagi kedua-dua kelas tersebut

ABSTRACT

FACIAL AND DENTAL ARCH FEATURES IN MALAY SCHOOL CHILDREN: A GEOMETRIC MORPHOMETRIC ANALYSIS

ABSTRACT

The association of malocclusion and soft tissue facial features remains controversial and is not fully understood. Prior to orthodontic treatment, observation and assessment of patient's soft tissue facial feature may provide clues on the etiology of the malocclusion. Therefore, the aim of this study is to look at the association of dental arch and soft tissue facial features in Malay school children. The specific aim of this study is to quantify and localize differences in Class I and Class II facial soft tissue and dental arch feature using finite-element analysis. After obtaining the appropriate consent, Malay school children from Kota Bharu, Malaysia, were screened for dental occlusal characteristics. Fifty children with a mean age of 15 ± 0.7 years were included in this study and divided into two groups of 25 each. The first group had Class I occlusion. The second group had Class II malocclusion. A 3dMD stereophtogrammetry unit was used to capture the 3-D facial soft tissues using a standardized protocol. At the same time, dental impressions were taken for all children and dental study models were prepared. Seventeen homologous landmarks were digitized for the facial soft tissue and fourteen homologous landmarks were digitized for the upper and lower arches, using MorphoStudio™ software, and the Procrustes means were computed. The mean Class I and Class II configurations were subjected to finite-element analysis and canonical correlation analysis. The results of this study suggested that Class I and Class II facial soft tissue configurations were statistically different ($p<0.05$). Specifically, differences in midfacial area where an increase in size by 16-18% was found in Class II malocclusion. In contrast, nasal, mental, and upper and lower ear regions were generally decreased in size (by 14-16%).

On the other hand, Class I and Class II lower dental arch configurations were also statistically different ($p<0.05$). Specifically, asymmetric increase in size (11-20%) were localized in the labial segment of the canine and molar regions, while shape differences were evident throughout the lower arch in Class II malocclusion. Moreover, Class I and Class II facial soft tissue configurations and dental arch feature were also significantly correlated ($p<0.001$) using canonical correlation analysis. In conclusion, facial and dental arch geometric morphometric differences between Class I and Class II malocclusion were identifiable using finite-element analysis, and Class I and Class II facial soft tissues and dental arch features are closely correlated. Further investigation is needed to identify functional features that are associated with the disruption of the normal pattern of facial growth and development.

CHAPTER ONE

INTRODUCTION

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INTRODUCTION

1.1. Background

Historically, facial harmony was considered as one of the important goals in orthodontic along with good occlusion. Indeed, if the teeth were placed in optimal occlusion, good facial harmony would result (Park and Burstone, 1986). Consequently, Hambleton (1964) reported that facial outlines should be regarded as an important guide in correction of all malocclusions. Kasai (1998), suggested that facial soft tissue configurations might be as variable as malocclusions.

In another study, Foley and Duncan (1997) suggested that comprehensive evaluation of a patient's malocclusion and facial balance would be incomplete without inclusion of soft tissue components and subsequent changes that occur during growth or orthodontic treatment. Therefore, the soft tissues covering the face are important to the patient as well as the clinician (Singh et al., 2004a)

However, Blanchette et al. (1996) considered the facial soft tissues to be a dynamic structure that can develop along with or independent of their skeletal substructure.

Most patients who require orthodontic treatment are adolescents who will continue to grow, and the facial soft tissues will change in both size and proportion (Hambleton, 1964).

In addition, a harmonious soft tissue profile is an important goal in orthodontics, although sometimes difficult to achieve, partly because the soft tissue overlying the teeth and craniofacial structures is highly variable in its thickness (Kasai, 1998).

On the other hand, the role of the soft tissues in the etiology of malocclusion has to be considered, as only about 5% of malocclusions have a clearly identifiable cause, such as history of trauma to the condyles or some other pathology. The remaining 95% of malocclusions are almost always due to "variation" of normal development such as soft tissue variation and genetic factors (Turner et al., 1997). Indeed, the soft tissue environment is thought to produce an equilibrium in which various opposing forces are balanced to produce zero resultant force (Proffit, 1978).

As the soft tissue facial profile is a major determinant of orthodontic treatment choice, assessment of hard tissue relations alone is inadequate for successful diagnosis and treatment (Yogosawa, 1990).

A thorough knowledge of the changes that the soft tissue undergoes throughout life is essential for good treatment planning in both growing patients and adults (Turner et al., 1997).

Thus, by studying the normal changes that occur in the facial complex, the clinician can identify and diagnose existing abnormalities with the purpose of providing optimal treatment for the patient. It is essential for clinicians to be aware of how the face changes and develops, where these changes occur, and when these changes usually take place (Bishara, 2000).

1.2 Statement of the problem

Published literature regarding the soft tissue facial profile and its relationship with underlying malocclusions and crowding of the dental arches is minimal in comparison with the numerous articles that can be found concerning dentoskeletal changes that take place during orthodontic treatment. Hence, this study was undertaken to investigate the relationship between facial soft tissues and underlying malocclusions. It is aim to determine the geometric morphometric difference between Class I and Class II malocclusion.

1.3 Hypothesis

There is an association between soft tissue facial features and malocclusions in Malay children aged 13 to 17 years old.

1.4 Objectives

1.4.1 General objectives

The aim of this study is to investigate the association between facial and dental arch features in Malay schoolchildren.

1.4.2 Specific objectives

II. To quantify and localize geometric morphometric differences in Class I and Class II malocclusion and facial soft tissues.

III. To study the relationship between facial soft tissue characteristics and dental arch features in Malay schoolchildren.

1.5 Significance of the study

The results of this study will depict facial features associated with malocclusions and will identify morphologic differences between Class I and Class II malocclusions. The long-term objectives of this study are to identify functional features that are associated with disruption of the normal pattern of facial growth and development and to determine how malocclusions can be minimized or prevented.

1.6 Assumptions

It is assumed that all diagnostic materials and methods utilized in this study, such as alginate impressions and study models, were taken and prepared in a consistent manner according to professional standards, and those potential errors, such as distortion of impressions, dental cast trimming and polishing errors are negligible.
It is also assumed that all landmarks that were used were located in their correct anatomical location for all the study subjects.

1.7 Inclusion criteria

All subjects analyzed in this study are healthy patients with normal craniofacial profile and with no previous history of orthodontic treatment or craniofacial trauma. All subjects analyzed in this study are free from any medical condition that could affect their normal growth and development.

CHAPTER TWO

LITERATURE REVIEW

CHAPTER TWO

LITERATURE REVIEW

2.1 Background

The analysis of the soft tissues is the critical step in orthodontic treatment plan decision. Proffit et al., (2000) suggested that in the treatment of malocclusions the facial outlines should be regarded as a guideline in determining proper treatment. Therefore, the clinicians should be able to detect if the characteristics of the face conform to a certain standard, and whether individual features, such as the forehead, nose, chin, and lips, are asymmetric and disharmony, and if so, what treatment is needed (Ackerman and Proffit, 1997).

Hambleton (1964) reported that in the Downs and Steiner's analyses, the soft tissues had not been taken directly into consideration.

Later, Park and Burstone (1986) suggested that it was possible to describe how facial morphology grew and developed by studying the growth changes of the soft tissue facial structures. They agreed with other studies that some parts of soft tissue profile did not directly follow the dentoskeletal profile.

Similarly, Bishara (2000) studied the magnitude and direction of change in facial parameters and reported certain standard deviations in facial height, depth and width.

2.2 The importance of soft tissues of the face

The morphologic relationships and proportions of the nose, lips, and chin determine facial harmony in orthodontics (Ferrario et al., 2003). The balance among these anatomic structures can be altered by both growth and orthodontic treatment, the orthodontist must understand not only the changes that occur with treatment but also the amount and direction of growth expected in the facial structure (Bishara, 2000).

In one of the quantitative studies on soft tissue facial growth, Genecov et al. (1990) suggested that in both males and females the anteroposterior growth and subsequent increased anterior projection of the nose continued even after skeletal growth subsided. Interestingly, subjects with Angle Class II malocclusions exhibit a more pronounced elevation of the bridge of the nose than Class I subjects. Configuration of the dorsum of the nose in the Class II subject also followed the general convexity of the Class II face, while Class I subjects tended to have a straighter nose (Ferrario et al., 1994).

Genecov et al. (1990) pointed out that in white Caucasian females, nasal projection remains constant from age 12 to 17 years. In contrast, nasal projection in white Caucasian males from aged 12 to 17 years continues, with greater growth rate resulting in a greater degree of nasal prominence in males of aged 17 years.

This was of clinical important because an orthodontist evaluating a 12-year-old female with Class II characteristics could reasonably expect only minimal increases in nasal projection over next 2 years. However, in a male of the same age, any procedures that result in upper lip retraction may produce a less than optimal final relationship between the lips and nose.

Buschang et al. (1993) quantified the dorsum growth and suggested that the shape changes of the nasal dorsum are most closely related to angular changes of the lower dorsum and nasal tip.

Additionally, nasal tip projection shows an early sharp peak for boys in their 13th to 14th year. This peak suggests that the nose exhibits an adolescent growth spurt in both gender but more significantly in males (Graber, 2000). Therefore, the soft tissue components of the nose grow at different times and varying direction according to gender.

Sexual dimorphism may also apply to other soft tissue features. For example, Genecov et al. (1990) reported that the soft tissue chin thickness in females aged 7 to 9 years (13mm) was greater than in males but both groups attained a similar soft tissue chin thickness by age 17 years.

Foley and Duncan (1997) reported that nasal tip increased significantly in all ages, thus of clinical important as continued soft tissue movements throughout the 14- to 20-year age period affect treatment planning, maintenance of the post treatment profile, and post treatment occlusal retention (Foley and Duncan, 1997).

Lip separation at rest is common in growing adolescents. Hashim at al (1997) demonstrated that lips grow in length and thickness by age and this growth in both dimensions is more marked in male subjects than in females.

The clinical important of this study according to Graber (2000) is that most children with lip incompetence at age of 6 years may experience self-correction by age 16 years. Therefore, knowledge of the growth of the soft tissue components of the face and the relationship between soft tissues and hard tissues is an important aspect in orthodontic diagnosis and treatment planning.

2.3 The influence of soft tissues on the dental arch

Currently, there is renewed interest not only to facial esthetics but also in the relationship of the soft tissues to the hard tissues, and the functional importance of the soft tissues (Singh et al., 2004a). It has been noted that the soft tissue environment is thought to produce a zone of equilibrium in which the dental arch resides, and in which various opposing forces are balanced to produce a zero resultant force on the dentition (Proffit, 1978).

This equilibrium, by definition, exists when a body at rest is subjected to forces in various directions. This description applies to the teeth, which occupy a position of balance determined by interactions between the tongue and the lips, the jaw relationship and occlusal forces. If the position of the teeth is to be altered and remain stable, another position of balance must be sought (Malcolm and Richard, 2000).

Earlier, Proffit (1978) classified the forces that act on the teeth as intrinsic forces, (which come from the tongue and lips), extrinsic forces (from sucking habits and orthodontic appliances, forces from dental occlusion, and forces from periodontium).

In spite of continuous interest in the influence of the soft tissues surrounding the dental arches on the position of the teeth, this influence is far from clear.

There is, however, evidence that the soft tissues may play an important role in determining the position of the teeth, and evidence regarding the importance of the soft tissues in treatment planning (Turner et al., 1997).

Blanchette et al. (1996) suggested that facial soft tissues are dynamic structures that can develop along with or independent of their skeletal substructure. Furthermore, the soft tissue variation in thickness, length and tonicity may have an effect on the position and relationship of the facial structures (Blanchette et al., 1996).

It has been previously assumed that the facial contours are primarily the results of underlying hard tissue position with an overlying soft tissue drape (Foley and Duncan, 1997).

This knowledge of growth of the soft tissue components of the face is very important as the face is now considered as a major determinant of treatment choice (Nanda and Ghosh, 1995). Assessment of hard tissue relation alone is considered inadequate for successful diagnosis and treatment planning.

In previous study, Proffit (1978) suggested that forces are exerted on the dental arches by the tongue and the circumoral musculature. The forces from tongue have consistently been found to be greater than those from the lips (Frohlich, 1990).

There is, however, no simple balance relationship between forces acting on the teeth from outside of dental arch (that is from the lips and cheeks), and forces from the tongue on the inside. On other hand, changes in soft tissue pressure might be expected to produce changes in tooth position, and may be one of the causes of the increase in lower arch crowding (Richardson, 1997).

Therefore, the association between soft tissue and spacing in dental arch has not been clarified and the question of the etiology of crowding still poses a classical problem in orthodontics.

Several hypotheses have been advanced to explain the etiology of crowding. For example, one-hypothesis states that the crowding occurs because of a discrepancy between the size of the teeth and the size of the jaws (Howe et al, 1983). Other suggestions are late mandibular growth, skeletal structure and complex growth pattern, soft tissue maturation, periodontal forces, tooth structure, occlusal factors, and connective tissue changes (Richardson, 1994).

Solow and Kreiborg (1977) suggest that head extension induces a stretch of the soft tissue of the face and neck, thereby increasing the forces of the lips and other facio-cervical muscles against the face and dentition. Another study by Solow and Sonnesen, (1998) introduces head position as a factor, which could affect the occurrence of crowding in the dental arch.

In addition, Oulis et al. (1994) suggests nasal mucosal swelling and airway obstruction as one the factor contributing to the development of crowding.

2.4 Contributions of the tongue, lips, cheeks to malocclusions

The tongue, functioning mainly in conjunction with the lips and cheeks, is one of the major guiding forces for erupting teeth (Frohlicht, 1990). The extrinsic muscles of the tongue are attached to the medial aspect of the mandible, the hyoid bone, the palate and the styloid process.

A relationship has been suggested between tongue size and incisor position, such that a large tongue causes proclined lower incisors and that, as the tongue maintains a constant relationship with the mandibular dentition, it may control mandibular tooth position (Turner et al., 1997).

In contrast, tongue size in relation to the size of the lower arch is rarely at fault, but occasionally, if the mandible is larger than the maxilla, the tongue usually finds space between the upper and lower arches and prevents the full vertical development of the dento-alveolar structures, resulting in open bite of varying extent (Foster 1982).

Therefore, the positions into which the teeth naturally erupt and align themselves are the points of balance between the opposing forces exerted by the tongue and the lips (Profit, 1978). For example, if protrusion of the tongue is strong and the tension of the lips is weak, the teeth will protrude slightly.

Conversely, if the strength of the lips is strong and the tongue is weak, it is believed that the teeth will be retroclined (Foster, 1982). Therefore, the muscles of the tongue, lips and cheeks are of particular importance in guiding the teeth into their final position, and variation in muscle form and function can effect the position and occlusion of the teeth (Turner et al., 1997).

Similarly, the role of the lips in determining and contributing to the development of malocclusions is contentious (Lapatiki et al., 2002). There is some evidence that pressure from the lips on the teeth is a result of the incisor position (Jung, 2003). This observation led to an attempt to use lip exercises to alter tooth position. Correction was achieved in term of overjet and, indeed, for lip strength, but both relapsed after the treatment ceased (Thuer and Ingervall, 1990).

Turner et al. (1997) suggested that the favorable lip changes observed in such cases are mainly a feature of normal lip development, as the lower lip normally elevates between the ages of 9 and 11 years it is thought this change will help in improving lip tissue deficiencies and reducing the overjet.

It is common to find an abnormal lip activity in an individual with a malocclusion. For example, it is not unusual to see a "lip trap" in Class II division I cases with retroclined lower incisors (Lapatiki et al., 2002).

Clinically, it is found that where the lips are full and everted, both upper and lower labial segments are more often proclined (bimaxillary proclination), But in individuals with more vertically positioned or straight lips the upper and lower labial segments often show bimaxillary retroclination which suggests that lip coverage is an important aspect in the etiology of malocclusions (Foster, 1982) .

Lips can also contribute to the appearance of the facial profile. Thuer and Ingervall (1986) suggested that children with high lip pressure as in Class II malocclusion had more retrognathic facial type.

2.5 The masticatory musculature and its contribution to malocclusion

Masticatory function might influence the dentition in two ways; first by increasing the muscular forces, which lead to alteration in jaw and dental arch dimension and, second, by increasing the biting forces which may prevent the eruption of posterior teeth (Turner et al., 1997). Therefore, the muscles of mastication can play an important role in determining vertical face height.

Turner et al., (1997) stated that individuals with a short vertical face height have greater biting forces than long-faced individuals.

An investigation of occlusal forces in both average and long-faced children and adults found that up to 11 years of age there were no significant differences in the occlusal forces between average and long-faced children. However, in the adult population, long-faced individuals have significantly lower occlusal forces than adults with an average face height (Proffit, 1983).

Kayukawa (1992) compared four types of malocclusion and masticatory muscles activity, and suggested that muscle activities were significantly higher in patients with a deep-bite than in patients with any other type of malocclusion.

Furthermore, Kayukawa (1992) suggested that clinical evaluation of masticatory muscle activities may be useful in improving orthodontic treatment planning, and in determining the proper retention period after treatment.

2.6 Facial morphology and malocclusion

Good facial harmony would result if the teeth were placed in optimal occlusion (Park and Burstone, 1986). Previous studies (Creekmore et al., 1992; Klapper et al., 1992; McLaughlin and Bennett ,1995; Taner-Sarisoy and Darendelile, 1999) have compared the vertical and horizontal facial growth pattern and suggest that subjects with a vertical growth pattern have an increased total face height, especially the lower anterior face heightand, short mandibular ramus. The opposite are present in subjects with a horizontal characteristics growth pattern.

In contrast, other researchers (e.g., Isaacson et al., 1971; Trouten et al., 1983; Nanda, 1988) were trying to link the relationship between the facial profile and malocclusion and found that maxillary dental arches of subjects with a vertical pattern are narrower, with a tendency toward posterior cross-bite and anterior open bite. Broader dental arches and accentuated overbite were observed in subjects with a horizontal growth pattern.

It has been suggested that subjects with a long lower anterior face height have posterior teeth with greater buccal inclinations and longer functional lingual cusp, and, conversely, that subjects with a short lower anterior face height have a greater lingual inclination of the posterior teeth and longer buccal cusps (Isaacson et al., 1971; Schendel et al., 1976; Fish et al., 1978).

In contrast, Ross et al. (1990) found no statistical differences in molar inclination between these facial types. Tsunori et al. (1998) has confirmed some part of his hypothesis and found that the posterior teeth in subject with a short facial type were more lingually inclined than in those with a long facial type.

Recently, Janson et al., (2004) studied buccolingual inclinations of posterior teeth in subjects with different facial patterns and concluded that the maxillary posterior teeth of subjects with a vertical growth pattern had a significantly greater buccal inclination compared with those of subjects with a horizontal growth pattern. Moreover, they suggested that palatal expansion should not be carried out for borderline cases with strong vertical growth pattern patient preferring extractions instead.

Extractions usually have more favorable results in this facial type (Park and Burstone, 1986, McLaughlin and Bennett; 1995) and palatal expansion can increase the buccal inclination of the maxillary posterior teeth, thus jeopardizing maxillary expansion stability.

Another strong restriction to the nonextraction treatment of borderline cases with vertical patterns is that any protrusion of the mandibular incisors will worsen the profile, because lip incompetence is another characteristic associated with this facial type (Klapper et al., 1992; Yamaguchi and Nanda, 1991; Lai et al., 2000).

Similarly, Howe et al. (1983) suggest that treating the borderline patients with palatal expansion and buccal inclination of the mandibular posterior teeth is applicable for those with horizontal facial patterns, as compared with those with vertical growth patterns.

Therefore, because of the greater palatal inclination of the maxillary posterior teeth in this facial pattern, a greater maxillary expansion could be carried out without causing unfavorable buccal tipping of the posterior teeth, which could lead to a greater relapse of the expansion (Haas, 1980). Consequently, the greater the maxillary expansion performed, the greater the amount of space available to correct the crowding.

Siriwat and Jarabak (1985) studied the relationship between malocclusion and facial morphology. They found that a neutral pattern is dominant in Class I and Class II division 1 malocclusions

2.7 Effects of head position and head form on malocclusion

Variation in head posture and head form and their relation with dentofacial morphology and malocclusion have been evaluated in the previous study. Moreover, few studies link the association between head form and position and its effect in dental and skeletal features (Solow and Tallgren, 1976; Solow and Sonnesen, 1998).

In an earlier study, Solow and Kreiborg (1977) developed the soft tissue-stretching hypothesis, which suggests that head extension induces a stretch of the soft tissue of the face and neck, thereby increasing the forces of the lips and other faciocervical muscles against the face and dentition stretching of this convex soft tissue layer creates a dorsally directed force, which lead to forward directed component of the normal growth of the face.

Solow and Tallgren (1976) found an increase in lower incisor retroclination with extended head position. They have also observed a positive correlation between mandibular retrusion and head position. Consequently, Solow and Sonnesen (1998) conformed the associations between crowding and craniocervical posture. Their finding show that subjects with anterior crowding in the upper or lower anterior segments of the dental arch, had craniocervical angles that were on average 3-5 degrees larger than subjects without crowding

Similarly, Solow and Sonnesen (1998) described the association between malocclusion and head posture as the strongest evidence they had been able to observe. Huggare and Harkness (1993), performed a study of the head posture in 13 Class II and 17 Class I children and concludes that distal occlusion and increased over jet were associated with a flexed head posture.

Solow and Sonnesen (1998) has recently reported the association between head posture and spacing in dental arch to answer the question of the etiology of crowding, They suggested that extension of the craniocervical posture could be a contributory factor in the development of crowding, based their suggestion of the soft tissue-stretching hypothesis.

In addition, Archer and Vig (1985) studied the effect of head position on intraoral pressure in Class I and Class II cases showing pressure changes with changes in head position. They emphasized this result as an important finding, suggesting that pressure may be a variable in the form and function relationship that determines skeletal form and tooth position.

2.8 Airway obstruction and malocclusions

Considerable controversy exists regarding the relation between mouth breathing and the frequency of malocclusion. Weider et al. (2003) suggested that mouth breathing does not have any influence on dentofacial morphology. Lopatienė and Babarskas (2002) suggested that mouth breathing neither induces changes in jaw growth, nor malocclusion.

Archer and Vig (1985) suggested that obstruction of nasopharyngeal airways may trigger an extension of the craniocervical posture. This idea has subsequently been confirmed by a demonstration of an increase in craniocervical posture in children with adenoids (Archer and Vig 1985). But there has been a controversy in the literature about the possible role of adenoid enlargement in altering facial growth causing skeletal and dental abnormalities (Tourne, 1990).

Adenoids are normally large in children due to hypertrophy of the lymphoid tissue. Regardless of the etiology, enlarged adenoid result in nasal breathing difficulties from partial obstruction of the nasopharyngeal airway (Oulis et al., 1994). As a result of nasal airway obstruction, rhinitis, sinusitis and otitis media may develop. Furthermore, due to elevated nasal airflow resistance the child is forced to switch to mouth breathing (Tourne, 1990).

When children breathe through the mouth, the mandible is displaced downward and backward, the tongue is positioned downward and backward and the head is tipped back (Defabjanis, 2003).

Changes in the mode of breathing can affect the relationships of the teeth in the horizontal and vertical levels well as the direction of jaw growth. Oulis et al. (1994) suggested that children with nasopharyngeal obstruction from hypertrophied adenoid show longer total and lower anterior face height and tendency toward a retrognathic mandible compared to control children.

In follow up studies after adenoidectomy, Linder-Aronson et al (1993) found that, changed in the mode of breathing after adenoidectomy is associated with significant labial positioning of the incisor teeth, these differences in morphology suggest that the differences had been caused by the adenoid obstruction of the airway. Oulis et al. (1994) stated that a lowered position of tongue played a significant role, this posture change of the tongue and lips will lead to disturbance in the equilibrium established by the forces exerted on teeth by oral soft tissues.

Moreover, other studies (Schlenker et al., 2000, Weider et al., 2003 Defabjanis, 2003) have demonstrated that airway obstruction may have an important influence on facial form and it is often associated with adenoid fancies or long face pattern of growth.

Therefore, Defabjanis (2003) suggested that Angle Class II division I malocclusion is followed and aggravated by mouth breathing, caused by obstruction of the upper airways.

Lopatiene and Babarskas (2002) suggest that the main characteristics of the respiration obstruction syndrome are the presence of hypertrophied tonsils or adenoids, mouth breathing, open-bite, cross-bite and narrow external nares.

Other features according to Schlenker et al. (2000) include excessive anterior face height, incompetent lip posture mandibular plane, and V-shaped maxillary arch.

Lopatiene and Babarskas (2002) presented a hypothesis, stating that increased adenoids aggravate nasal breathing, which disrupts the balance of lingual, labial, and cheek muscles and they concluded that adenoids influence the appearance of skeletal and dento-alveolar deformities.

Harvold et al. (1981) had experimentally induced nasal obstruction in animals, which resulted in mouth breathing and entailed maxillary narrowing, lowered mandibular position, increased anterior face height, malocclusion and dental anomalies.

Further studies on human by Tomer and Harvold (1982) and Vickers (1998) showed that mouth breathing also influences the increase of the lower third of the face, mandibular rotation, and the excessive mandibular angle.
Moreover, nasal obstruction causes changes in muscular function, and dento facial feature (Lopatiene and Babarskas, 2002; Tomer, 1982; and Vickers, 1998).

Defabjanis (2003) suggested that facial form can be influenced by enlarged adenoids; He indicated that children with mouth breathing often develop a V-shaped maxillary arch.

Moss (1962) from his functional matrix theory mentions that bone responds to the influences of function and the adjoining soft tissue explains the narrow palate and long face seen in mouth breathers.

Many researchers have supported the relation between malocclusion and airway obstruction. For example, Oulis et al. (1994) found that 47% of children examined in their study had developed a posterior cross-bite, and the presence of cross-bite was high in children with severe airway obstruction. According to their study, the skeletal and muscular environment was responsible for the increased incidence of open bite, protrusive maxilla and buccal posterior cross bite noted in the sample.

The study by Lopatiene and Babarskas (2002) showed the significant association between nasal resistance and increased overjet, open bite and maxillary crowding. They also noted a tendency of greater nasal resistance in patients with the first permanent molars in Angle Class II relationship and a posterior cross-bite.

2.9 Geometric morphometric analysis of facial soft tissue and malocclusion

Comparing the anatomical feature of organism has been a central element of biology for centuries, by the mid of twentieth century, quantitative description of morphological shape was combined with statistical analysis and modern flied of morphometric begin (Adams et al., 2004).

Traditionally, morphometrics was the application of statistical analysis to a set of variables such as length, width, and height, but a shift occurred in the way that how morphological structures were quantified and how the data were analyzed.

This shift suggested methods that preserve complete information about the morphological structure throughout the analysis and this approached called geometric morphometrics. Therefore geometric morphometric is the statistical analysis of shape using landmarks data (Adams et al., 2004).

Geometric morphometric of the soft tissue variation are related to growth, development, treatment planning and prognosis of patients, Therefore, soft tissue morphometrics evaluations become a new area of interest (Singh et al., 2003b). One of those techniques that were used to look to the soft tissue configuration was finite element analysis (Singh et al., 2004b). Using this technique, change in morphology is viewed as a deformation of an initial geometric configuration, whose boundaries are formed by edges that connect anatomical landmarks, into a final form (Singh et al., 1997b).

Indeed, Finite element morphometry (FEM) has been employed previously in a study of cranial base anomalies (Grayson et al., 1985), as this method allows visualization of the magnitude and direction of the change (Battagel, 1995).

Finite element morphometric analysis provides information on deformation within the geometrical configuration and between the defining anatomical landmarks (Cheverud *et al.*, 1983; Lozanoff and Diewert, 1989; Lozanoff et al., 1994).

Moreover this technique has been applied to numerous problems in craniofacial growth and has contributed in biological information (Richtsmeier and Lele, 1990; Richtsmeier *et al.*, 1991; Diewert *et al.*, 1993; Kohn *et al.*, 1994).

Nevertheless, FEM has been extensively used to study the facial soft tissue and its component and also its capable of quantifying local shape and size change that highlight regionalized morphological difference between the objects. For example; Singh et al (1999c) examined the size and shape change and he concluded that the overall mean Korean and European-American soft tissue configuration differed statistically. For size change mean overall Class III soft-tissue configurations, Korean mental region is approximately 40% smaller but lower lip is approximately 29% larger than mean European American configuration.

In a previous study, Singh et al. (1998a) examined the components of soft tissue deformations in subjects with untreated angle's Class III malocclusions using thin-plate spline analysis and he concluded that children with Class III malocclusions demonstrate antero-posterior and vertical deformations of the maxillary soft tissue complex in combination with antero-inferior mandibular soft tissue elongation.

In the same year, Singh et al. (1998b) examined the morphological difference between prepubertal individual with Class III malocclusion and I and confirmed that the Class I and Class III mandibular configuration were significantly different and the greatest different in morphology arose in anterior-most mandibular region

Similarly (Singh et al., 1997b) examined the morphometric change of the cranial base in subjects with Class III malocclusion and he concluded that the shape of the cranial base differs in subjects with Class III malocclusion compared with the normal Class I configuration, due to failure of the cranial base to flatten during development.

)n other hand, Ferrario et al. (1999b) suggested that the three-dimensional facial norphometry method allowed the noninvasive evaluation of a large sample of subjects, eading to the definition of three-dimensional normative data about facial soft tissues. One way of investigating the soft tissue facial morphometric would be to compare the same soft tissue with different malocclusion. For example, Ferrario et al. (1994) compared the soft tissue facial morphometry in children with Class I and Class II occlusions and he conclude that Class II children had more convex faces in the sagittal plane and a less prominent mandible than Class I children.

Looking to the growth of soft tissue from morphometric point of view is another aspect of growth studies. For example, Franchi et al. (2001) analyzed the mandibular growth using thin-plate spline analysis and statistical significant changes in mandibular shape were found.

Other researchers prefer to use the morphometric analysis to evaluate the treatment outcome. For example study by Singh and Clark (2001) which they used finite element analysis to localized the mandibular change that occurred in Class II division I malocclusion treated with twin block appliance, a color-coded finite element scaling analysis revealed that in growing patients treated for Class II Division 1 malocclusions with Twin-block appliances, condylar growth, coronoid process remodeling, may reflect the correction of the underlying skeletal dysmorphology.

In contrast, FEM has been used also as a technique in the analysis of cleft palate dental arch form as this technique may help in understanding of the development, treatment planning, and prognosis of patients born with cleft lip and palate (McAlamey and Chiu, 1997).

2.10 Rationale of the study

As far as we are aware, there has been no study on the evaluation of the facial soft tissue and dental arch feature of Malay children aged 13 to 17 years using geometric morphometric technique. Most of the studies are using traditional measurements like lateral cephalometric and caliper. Therefore our aim of this research is to used Finite element analysis as useful tool to quantify and localized difference in Class I and Class II malocclusion in term of facial soft tissue as well as dental cast feature so that could highlight regionalized morphological difference.

Thus, this study may show better understanding of the growth and development of our Malay population and the result of this study could be one-step in helping to identify the facial feature that associated with malocclusion.