EFFECT OF REVERSE TWIN-BLOCK AND REVERSE PULL FACE MASK APPLIANCE FOR CLASS III MALOCCLUSION ON DENTO-FACIAL MORPHOLOGY IN MALAY POPULATION

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LIST OF SYMBOLS AND ABBREVIATIONS

+	Plus
±	Plus Minus
×	Multiplication
=	Equal
°	Degree
%	Percent
/	Or
>	Greater than
<	Less than
®	Registered
III	Three
CASSOS	Computer-Assisted Simulation System for Orthognathic Surgery
CBCT	Cone-Beam Computed Tomography
CT	Computed Tomography
CVM	Cervical Vertebral Maturation
dpi	Dots per inch
FR-3	Fränkel-III
g	Gram
HP	Hewlett-Packard
HREC	Human Research Ethics Committee
HUSM	Hospital Universiti Sains Malaysia
IBM	Computer Manufacturing Company

JEPeM	Jawatankuasa Etika Penyelidikan Manusia
JPEG	Joint Picture Experts Group
kVp	Kilo Voltage potential
m	Meter
mA	Milliampere
MITK	Medical Imaging Interaction Toolkit
Mm	Millimeters
N	Total Sample
n	sample
NY	New York
PC	Personal Computer
RME	Rapid Maxillary Expansion
SD	Standard Deviation
SPSS	Statistical Package for the Social Sciences
™	Trademark
USA	United States of America
USM	Universiti Sains Malaysia

KESAN BLOK KEMBAR BERBALIK DAN APPLIANS TOPENG MUKA TARIKAN BERBALIK UNTUK MALOKLUSI KELAS III PADA MORFOLOGI DENTO FASIAL POPULASI MELAYU

ABSTRAK

Rawatan blok kembar berbalik dan topeng muka tarikan berbalik memberi kesan perubahan pada struktur dento fasial termasuklah perubahan pada tisu-tisu lembut. Sorotan kajian mengenai pengurusan maloklusi kelas III dan kesan rawatan aplians yang digunakan kepada populasi Melayu amatlah terhad. Oleh itu, matlamat kajian keratan lintang ini adalah untuk membuat perbandingan dan analisis ke atas perubahan kranofasial yang disebabkan oleh blok kembar berbalik dan topeng muka tarikan berbalik dalam kegigian campuran awal dan akhir kalangan kanak-kanak Melayu yang tergolong dalam maloklusi kelas III. Data kajian diambil semasa pra rawatan dan pos rawatan selafogram lateral kegigian campuran kanak-kanak melayu. Seramai 49 orang kanak-kanak dirawat dengan blok kembar berbalik dan 46 orang kanak-kanak pula dirawat dengan Topeng muka tarikan berbalik. Kanak-kanak ini dibahagikan kepada dua kumpulan iaitu kegigian campuran awal (8-9 tahun) dan kegigian campuran akhir (10-11 tahun). Perubahan rawatan dinilai menggunakan analisis Holdaway, analisis Ricketts, analisis Tweed, analisis ruang salur udara farinks dan analisis Steiner dengan menggunakan perisisan CASSOS dan MITK. Statistik deskriptif dan regressi linear berganda dijalankan dengan tahap kesignifikan ditentukan pada 0.05. Hasil kajian menunjukkan kesan rawatan blok kembar berbalik dan topeng muka tarikan berbalik mempunyai beza keertian yang signifikan termasuk ketaksamaan jantina. Namun begitu

pengesanan beza keertian secara statistik diklinikal amatlah minimum kecuali proklinasi insisor atas dan protusi bibir atas. Kanak-kanak yang dirawat dengan topeng muka tarikan berbalik mempunyai insisor atas yang lebih condong dan bibir atas yang lebih menjulur keluar. Keputusan juga menunjukkan bahawa kumpulan umur yang berbeza tidak mempunyai impak keertiaan terhadap kesan rawatan. Rawatan maloklusi kelas III bagi kanak-kanak melayu boleh ditangguh sehingga tahap kegigian campuran akhir kerana tiada beza keertian dicatatkan dalam kesan rawatan kegigian campuran awal mahupun akhir. Penangguhan ini dapat memberi komplians pesakit yang lebih baik dengan kos dan masa rawatan yang lebih rendah. Pelan rawatan untuk samada kanak-kanak lelaki atau perempuan juga boleh disamakan memandangkan keputusan perbezaan jantina tidak jelas secara klinikal. Kesimpulannya, rawatan menggunakan Topeng muka tarikan berbalik dalam kalangan kanak-kanak Melayu maloklusi kelas III yang mempunyai kegigian campuran telah memberikan hasil rawatan yang lebih baik dimana proklinasi insisor atas dan protrusi bibir atas adalah lebih baik berbanding dengan rawatan blok kembar berbalik.

EFFECT OF REVERSE TWIN-BLOCK AND REVERSE PULL FACE MASK APPLIANCE FOR CLASS III MALOCCLUSION ON DENTO-FACIAL MORPHOLOGY IN MALAY POPULATION

ABSTRACT

The treatment effect of Reverse Twin-Block and Reverse Pull Face Mask definitely produces some changes in the dento-facial structures, including the soft tissue. There is a lack of available literature in the management of Class III malocclusion as well as treatment effects of these particular appliances in Malay population. This cross-sectional study was aimed to compare and analyse the craniofacial changes produced by Reverse Twin-Block and Reverse Pull Face Mask in early and late mixed dentition of Malay children having Class III malocclusion. Data consisted of pre- and post-treatment lateral cephalograms of 95 mixed dentition Malay children, 49 children treated by Reverse Twin-Block and 46 children treated by Reverse Pull Face Mask were divided into early (8-9years) and late (10-11years) mixed dentition groups. Treatment changes were assessed by Holdaway's analysis, Ricketts analysis, Tweed's analysis, pharyngeal airway space analysis and Steiner's analysis using CASSOS and MITK software. Descriptive statistics and multiple linear regression were performed with the significance level set at 0.05. The result of the study revealed that the treatment effect of Reverse Twin-Block and Reverse Pull Face Mask has some statistically significant differences including gender disparities. However, these statistically significant changes were very minimum to notice clinically, except upper incisor proclination and upper lip protrusion. Reverse Pull Face Mask treated children had more proclined upper incisors and more

protruded upper lip. The result also shows that different age group has no significant impact on the treatment effect. As, no significant differences were noted in treatment effects of early and late mixed dentition groups, the treatment of Class III malocclusion in Malay children can be delayed until late mixed dentition stage. It provides better patient compliance with less treatment time and cost. The treatment plan should be same for both male and female children, as the gender disparities found in the result were clinically unnoticeable. In conclusion, Reverse Pull Face Mask produced better treatment outcome with more proclined upper incisor and more protruded upper lip than Reverse Twin-Block in mixed dentition Malay children with Class III malocclusion.

CHAPTER ONE

INTRODUCTION

Treatment of Class III malocclusion in mixed dentition children is amongst the most challenging orthodontic cases faced by both the clinicians and the researchers. Facial aesthesis, functional efficiency, and balanced occlusion with stable dentition are the primary goals of orthodontic treatment (Proffit *et al.*, 2011). Reaching the treatment goals along with dealing the growth changes is the most crucial part. Proper treatment planning necessitates a vast and concurrent knowledge related to the age, gender, race, and etiology of malocclusion.

1.1 Background of the Study

The origin of Class III malocclusion may be skeletal, dental or functional. The skeletal Class III malocclusion is characterized by the presence of maxillary retrognathism or mandibular prognathism or a combination of both exhibiting a concave facial profile (Canturk and Celikoglu, 2015; Cordasco *et al.*, 2014). Treatment of Class III malocclusion depends upon the age of the patient and the pattern and severity of malocclusion. Malocclusion can be treated by orthodontic camouflage, appliance therapy and surgical correction. Orthodontists prefer to treat Class III malocclusion during mixed dentition stage to utilize the effect of growth spurt as well as reducing the risk of future surgical intervention (Lione *et al.*, 2015; Mandall *et al.*, 2016). Mixed dentition stage is the crucial time to start orthodontic appliance therapy as the sutures are not calcified yet and the growth is not completed. The growth of maxillo-mandibular complex can be redirected, repositioned or remodeled by the use of orthodontic appliances (Ngan, 2001).

Reverse Pull Face Mask, Chin Cup, Fränkel III (FR-3), Reverse Twin-Block, Reverse Bionator are the orthodontic appliances used to treat Class III malocclusion. Treatment effect may be skeletal, dento-alveolar or both. Several studies reported the successful use of Reverse Pull Face Mask in treatment of Class III malocclusion (Baccetti *et al.*, 1998; Kilicoglu and Kirlic, 1998; Lione *et al.*, 2015; Ngan *et al.*, 1996; Westwood *et al.*, 2003). Reverse Pull Face Mask appliance is widely used in the treatment of Class III malocclusion as it modifies the growth of both maxillary and mandibular skeletal and dento-alveolar structures. Some studies incorporated rapid maxillary expansion (RME) along with the Reverse Pull Face Mask therapy (Celikoglu *et al.*, 2015; Hino *et al.*, 2013; Masucci *et al.*, 2014; Nienkemper *et al.*, 2013). Studies have also reported of the treatment changes on pharyngeal airway space (Oktay and Ulukaya, 2008). The drawbacks of Reverse Pull Face Mask appliance are the appearance and the conspicuous design. Children often refuse or discontinue wearing the appliance for the fact of feeling uncomfortable and being bullied by friends. On the other hand, FR-3 being an intra-oral appliance takes double time to produce the similar treatment effect (mostly dento-alveolar), which is both time and money consuming (McNamara *et al.*, 2011). Reverse Twin-Block is also an intra-oral appliance having esthetic appearance and the treatment period is similar to Reverse Pull Face Mask. Few studies has reported the treatment effect of Reverse Twin-Block, mostly some case reports revealing successfully corrected Class III malocclusion and reported of the treatment effect being mostly dento-alveolar (Kidner *et al.*, 2003; Mittal *et al.*, 2017). To choose between the appliances, their treatment effects must be compared in a detailed manner covering soft tissue, craniofacial and dento-alveolar changes. Although, the comparison of treatment effects of Reverse Pull Face

Mask and Reverse Twin-Block has been reported in one study focusing on some primary cephalometric measurements only (Seehra *et al.*, 2012). Till date, a detailed comparison of the treatment effects of Reverse Pull Face Mask and Reverse Twin-Block is not done.

Another question arises in the treatment of mixed dentition children is whether to start the treatment at early (erupting permanent incisors and/or first molars) or late (erupting permanent canines and/or premolars) mixed dentition stage (Baccetti *et al.*, 1998). The ideal time to start the treatment of Class III malocclusion is after the eruption of upper permanent incisors, that is the beginning of mixed dentition stage (Proffit *et al.*, 2007). But whether the treatment should be started immediately or can be delayed until late stage is still under doubt (Tai *et al.*, 2014). Some study found better treatment response at early mixed dentition stage (Baccetti *et al.*, 1998; Ngan, 2006). Contrary, some studies found no significant difference between early and late mixed dentition groups (Primozic *et al.*, 2017; Yuksel *et al.*, 2001; Zhang *et al.*, 2015). This leads to a dilemma in actual starting age of treatment. If the early stage shows better efficacy, there is no hesitation on starting the treatment at early mixed dentition stage. But if the response is equal in both early and late stages then there is no point of starting the treatment early. Beginning the treatment at early stage requires more time to convince the patient (due to younger age) along with more follow-ups. Together, these lead to a longer treatment period with high treatment cost. If both stages show similar treatment effects then starting treatment at late stage will reduce the treatment time and cost along with better patient compliance.

Usually, same treatment approach is planned for both male and female children, but do they response equally? Or there are some discrepancies in the treatment effects due to gender difference. This is an additional query we wanted to resolve in our study. No other

study has either compared the treatment effects of these two appliances on different age groups or checked for gender disparities. A thorough comparison of the treatment effects of Reverse Pull Face Mask and Reverse Twin-Block leading to dento-facial changes will not only help the researchers but also clinicians in planning a proper and effective treatment approach to Class III malocclusion in Malay children.

1.2 Gap Statement

A high prevalence of Class III malocclusion is associated with Malay and Chinese ethnic groups in Malaysia (Hardy *et al.*, 2012; Soh *et al.*, 2005; Woon *et al.*, 1989). This rate is highest among Malay ethnic groups 26.7% followed by Chinese ethnicity (22.9%) (Soh *et al.*, 2005). However, no study was found reporting treatment changes of Class III malocclusion in Malay population. There is a lack in the detailed treatment effects of Reverse Pull Face Mask and Reverse Twin-Block in Malay population in the available literature, despite of this particular type of malocclusion being highly prevalent in this ethnicity. This gap should be filled with quality researches to ease the treatment procedure. Therefore, this study was aimed on exploring and comparing the treatment effects on dento-facial changes in mixed dentition Malay children having Class III malocclusion treated with Reverse Pull Face Mask and Reverse Twin-Block appliance, in relation to age, gender and type of appliance.

CHAPTER TWO

LITERATURE REVIEW

Treatment of Class III malocclusion is challenging, particularly when it is skeletal in origin. The outcome after cessation of growth is unpredictable, which makes the treatment of this particular type of malocclusion challenging to the orthodontists (Franchi *et al.*, 2014; Westwood *et al.*, 2003). As the growth pattern varies in different races and individuals also, a vivid knowledge on growth and development is obligatory. The etiology of Class III malocclusion along with the treatment options and the treatment effects are also the topic of interest. Any study regarding treatment of Class III malocclusion in Malay population should be explored.

2.1 Mixed Dentition Stage

The mixed dentition stage begins with the eruption of the first permanent tooth, usually the lower central incisors and ends with the shedding of the last deciduous tooth (Bishara, 2001a). Generally, the first permanent tooth to erupt is the lower central incisor and the first permanent molar, which occurs at about age six (both chronological and dental). This is followed by the eruption of the upper central incisors and the first permanent molars at about age seven (Proffit *et al.*, 2007). However, the eruption age may vary from six months to one year earlier or later depending on different races and individuals. Early mixed dentition stage begins with the eruption of the permanent incisors and/or first molars and the late mixed dentition stage begins with the eruption of the permanent canines and/or premolars (Baccetti *et al.*, 1998). By the time of age eight to nine, all the permanent central incisors and the first molars should be erupting or have erupted. Accordingly, all the permanent canines and premolars start erupting by the age of ten to

eleven. This is the reason of considering eight to nine years as early mixed dentition stage and ten to eleven years as late mixed dentition stage.

2.2 Growth and Development during Mixed Dentition Stage

Growth and development, these two terms are keenly related. Adolescence or puberty is the transitional period between the juvenile stage and adulthood. At this stage of life sexual maturity is attained by the effect of sex hormones. The raised level of sex hormones, mainly oestrogen for females and testosterone for males, apart from developing the secondary sexual characteristics also takes part in acceleration of bone growth, including the jaw bones. This period is of great importance to orthodontists as some significant changes in dento-facial development take place, namely transition from mixed to permanent dentition, introducing facial growth spurt and differential growth of jaws which contributes greatly in the occlusal development (Bishara, 2001b; Proffit *et al.*, 2007). Thus, the adolescent period coincides with mixed dentition stage. At this stage, the mandibular growth is more than the maxillary growth. This differential jaw growth results in less convex facial profile with a prominent chin. To utilize the growth spurt, orthodontic appliances are best to be used at this stage (Proffit *et al.*, 2007).

The growth of the maxilla and the nose happen together as a naso-maxillary complex. The growth of the maxilla occurs downwards and forwards by both active growth of naso-maxillary sutures and passive displacement by the growth of cranium. On the other hand, mandibular backward rotation is caused by the maxillary retrusion or a decrease in the cranial base growth (Bishara and Ferguson, 2001; Proffit *et al.*, 2007). During mixed dentition stage, the mandibular growth is also downwards and forwards (Kelly *et al.*, 2017). Bone resorption at the anterior border and deposition at the posterior border of

rami aids in the anteroposterior growth of mandible and creates a space for permanent molars. The prominence of chin is another feature of this stage. This is mainly due to the bony resorption of the area just above the chin and partly by the bony deposition on the chin (Bishara and Ferguson, 2001; Proffit *et al.*, 2007).

Not only the hard tissues but the soft tissue changes that take place during mixed dentition stage are of similar importance in orthodontic treatment planning. Although, the soft tissue changes are influenced by the underlying hard tissue changes but the variation in soft tissue thickness also contributes greatly. The facial convexity is changed and the facial profile angle is decreased during this stage. The contributing factors are bone deposition on chin, increased soft tissue thickness of the chin and philtrum. The lips become thin during mixed dentition stage; this is partly by the increased prominence of the nose and chin and partly by the eruption of permanent incisors. Lips show a slow protrusion rate during this stage (Primozic *et al.*, 2017). Gender disparity is also noticed in the lip thickness. Female children exhibit thinner lips than the male children, although the difference is more prominent after the age of 12 years (Genecov *et al.*, 1990; Nanda *et al.*, 1990).

The pharyngeal airway can be divided into upper and lower pharyngeal airways (Mcnamara, 1984). It has been reported that the formation and maturation of pharyngeal airway space is established during early growth periods and it remains quite stable from age 6-17 years (Mislik *et al.*, 2014). The mixed dentition stage falls within this age range.

2.3 Determination of Age

The sequential events of growth vary at different stages of life. Proper treatment planning is correlated with the maturational age of the patient. There are chronological age, dental age, skeletal maturity indicator and others to determine the age. Skeletal maturity can be determined by using hand-wrist x-ray or lateral cephalogram. Now–a-days, hand-wrist x-ray is excluded mostly as it is unethical to do additional exposure to radiation. Alternative to hand-wrist x-ray, lateral cephalogram is already available to the orthodontists and it can be used to detect skeletal maturation stage by Cervical Vertebral Maturation (CVM) method (De Fuentes *et al.*, 2015). However, a skeletal maturity index for particular population is required to correlate. Otherwise there is a chance of bias if the data of one population is matched with other. Contrary, chronological age is the widely used method in researches to determine age (Celikoglu *et al.*, 2015; O'Brien *et al.*, 2009a; Seehra *et al.*, 2012; Wiedel and Bondemark, 2015). One study reported of no significant advantage of hand-wrist x-ray and CVM method for skeletal maturation over chronological age (Mellion *et al.*, 2013). Another study found significant correlation in between CVM method and actual chronological age (Khan *et al.*, 2017). High correlation coefficient between chronological age and dental age was also found in another study, but it was on Brazilian population (Kurita *et al.*, 2007). According to the literature review, skeletal maturity indicator varies in different races (Montasser *et al.*, 2017). Individual skeletal maturity index is required for each population. Otherwise, it is safe to use chronological or dental age.

2.4 Class III Malocclusion

Angle defined Class III malocclusion as the occlusal relationship of the first permanent molars characterized by the mesial positioning of the lower molar in relation to the upper molar. This classification of Angle accurately describes the anteroposterior relationship. In 1992, the British Orthodontic Society suggested another classification of malocclusion describing transverse and vertical relationships (Proffit *et al.*, 2007). A study was published classifying malocclusion based on incisor relationship; characterizing Class III malocclusion as the lower incisal edges lying anterior to the cingulum plateau of the upper incisors with overjet reduced or reversed (Williams and Stephens, 1992). This anteroposterior, transverse or vertical maxillo-mandibular discrepancy may be solely dental, skeletal or a combination of both. In case of skeletal Class III malocclusion, any combination of deficient maxillary growth and excessive mandibular growth can be observed. Whether anteroposterior or vertical, both types of maxillary deficiency result in Class III malocclusion. A retruded small maxilla directly results in Class III malocclusion. But when the maxillary deficiency is vertical, the compensatory upward and forward rotation of mandible creates an image of mandibular prognathism. Class III malocclusion due to true mandibular prognathism is a tough one to treat (Proffit *et al.*, 2007).

2.5 Etiology of Class III Malocclusion

The factors responsible for developing malocclusion are basically genetic or hereditary and environmental (Ackerman *et al.*, 2011; Staley, 2001). A detailed knowledge about the etiology of malocclusion helps to make a proper treatment plan.

Recent genetic studies have identified genes those are susceptible in developing Class III malocclusion (Xue *et al.,* 2010). Few studies have confirmed that heredity is responsible to carry these genes among the family members (El-Gheriani *et al.,* 2003; Watanabe *et al.*, 2005). Different researchers have identified different genes contributing to Class III malocclusion in different races (Frazier-Bowers *et al.,* 2009; Yamaguchi *et al.,* 2005). This could help the orthodontists to plan for early treatment approach that will prevent the progress of Class III malocclusion.

Environmental factors contributing to the malocclusion must be kept in mind while planning treatment and the influence of this causative factor should be terminated. Habit, trauma, caries, premature loss of primary dentition, periodontal disease, chronic nasal obstruction, mouth breathing are primary environmental factors leading towards malocclusion (Staley, 2001). Children may habitually bring the mandible forward for incisal interference or to create occlusal contact due to premature loss of the primary molars. An abnormally large tongue or as a symptom of early thyroid-deficiency often lead to mandibular prognathism (Proffit *et al.,* 2007).

2.6 Choice of Treatment

Class III malocclusion in growing children is treated by the orthopedic appliances by craniofacial growth modification. Whereas, in adults, Class III malocclusion is treated by the combination of orthognathic surgery and orthodontic treatment (Chang *et al.,* 2006).

For the anteroposterior and vertical deficiency of the maxilla, a forward and downward maxillary protrusion is preferred. For this purpose, Reverse Pull Face Mask is incorporated. FR-3 is another functional appliance used for maxillary protraction.

However, available data showed little maxillary protraction was resulted with FR-3 appliance, most of the changes were dental (Proffit *et al.*, 2007). Reverse Twin-Block is a functional appliance with great patient compliance to treat Class III malocclusion because of its inconspicuous design and esthetic appearance. After wearing the appliance, the noticeably improved appearance helps to motivate the patient (Clark, 1997b). In case of mandibular prognathism, the treatment of choice is redirecting or restraining the mandibular growth. Chin cup/chin cap is usually used for this purpose. Other functional appliances can also be used. According to the literature, mandibular growth restraining with any of these appliances is quite difficult. The major effect can be seen as downward and backward rotation of the mandible which retruds the mandible and increases the lower facial height (Proffit *et al.*, 2007). A detailed description of Reverse Pull Face Mask and Reverse Twin-Block is given later.

2.7 Timing of Treatment

For a long time, there was controversy in treatment of Class III malocclusion, whether to start the treatment early or defer until the growth is completed. The normal pattern of growth in jaw bones during mixed dentition stage shows discrepancy in the maxillo-mandibular relationship. The direction of growth is forward and downwards for both jaws but the mandibular growth is more than the maxilla. If Class III malocclusion is left untreated at this stage, a more prognathic mandible with prominent chin is resulted. The malocclusion is fully developed and severe in form which can be corrected by surgical approach only. Then it seemed more sensible to treat the malocclusion early before it reaches the full abnormal form (McNamara *et al.*, 2011; Saadia and Torres, 2000). The benefit from this early approach was favourable sutural response along with improved

facial profile and self-esteem excluding any discrepancies of centric relation and centric occlusion (Ngan, 2006). The treatment of Class III malocclusion should be started after the eruption of upper permanent incisors and first molars, that is during the mixed dentition stage (McNamara *et al.*, 2011; Proffit *et al.*, 2007). But, there is a dilemma whether the treatment should be started immediately or can be delayed until late stage (Tai *et al.*, 2014). Better treatment response at early mixed dentition stage was reported by some researchers (Baccetti *et al.*, 1998; Ngan, 2006). On the other hand, similar treatment response was found in some studies who reported no significant difference between early and late mixed dentition stage (Primozic *et al.*, 2017; Yuksel *et al.*, 2001; Zhang *et al.*, 2015). The age range advised by many researchers is quite large. It starts from early mixed dentition, before eight years of age, up to twelve years to even during puberty also (Baccetti *et al.*, 1998; Halicioglu *et al.*, 2014; Kapust *et al.*, 1998; Merwin *et al.*, 1997). To plan a treatment protocol the starting age of treatment is very crucial.

2.8 Reverse Pull Face Mask Appliance

Reverse Pull Face Mask is the orthopedic appliance used in the treatment of Class III malocclusion in growing children. It is an extra-oral appliance with three basic components; a face mask, a maxillary splint and elastics. This facemask was popularized by Delair (1971-1976) and later modified by Petit (1982-1983) (Carmen Ruiz López and Sáez Espínola, 2015). Both Delair and Petit type of facemasks are being used successfully. Some studies incorporated RME to disrupt the circummaxillary sutures and get a better treatment outcome (Ghoneima *et al.*, 2011; Halicioglu *et al.*, 2014). The effect of RME on sutures are described differently by researchers. The effect included opening of mid-palatine sutures, downward maxillary movement along with anteroposterior

displacement, displacement of palatine bones, and forceful distortion of sphenoid and zygomatic sutures also (Ghoneima *et al.*, 2011; Jafari *et al.*, 2003; Timms, 1980; Wertz and Dreskin, 1977). Despite this fact several studies also reported of finding no significant differences between the treatment protocol with RME and without RME (Halicioglu *et al.*, 2014; Kim *et al.*, 1999a). Reverse Pull Face Mask should be incorporated after the eruption of first permanent molars as it can be included as an anchorage unit. It also acquires anchorage from forehead and chin. It has an extra-oral and an intra-oral part. The extra-oral part consists of a forehead pad and a chin pad joined by heavy steel supported rod. The forehead and chin pads may be custom made or commercially available. The intra-oral part is composed of a maxillary splint, which may be banded, bonded or removable. The bonded splint usually creates hygiene problem and that is the reason of not using it widely. Arch expansion screw (for RME) or other components are incorporated in the maxillary splint. The facemask and maxillary splint are linked together with heavy elastics. The maxillary splint has hooks at the canine-primary molar area for the attachment of elastics. It is the area which provides force vector near the center of resistance of the maxilla and restricts maxillary rotation (Proffit *et al.*, 2007). The direction of force vector varies in different studies as it depends upon the desired clinical effect (Yepes *et al.*, 2014).

Approximately 340g of force is applied per side of the appliance for 14 hours a day (Proffit *et al.*, 2007). However, the amount of force applied per side varies in large scale in different studies (Yepes *et al.*, 2014). Few studies applied very low force, less than 300g (Pangrazio-Kulbersh *et al.*, 1998; Suda *et al.*, 2000). Application of 300-400g force was reported by most of the studies (Baccetti *et al.*, 1998; Merwin *et al.*, 1997; Ngan *et*

al., 1996; Saadia and Torres, 2000; Tortop *et al.*, 2007). Some studies reported of application of higher force; 500g or more (Grandori *et al.*, 1992; Keles *et al.*, 2002). The optimal force to be applied per side should be the smallest force producing clinically significant skeletal movement along with a minimum amount of dental movement and this could be ranged from 300-400g (Yepes *et al.*, 2014). There is also controversy in duration of use of the appliance. Some studies reported 12-14 hours a day, some reported 14-16 hours per day (Baccetti *et al.*, 1998; Merwin *et al.*, 1997; Ngan *et al.*, 1996; Saadia and Torres, 2000; Tortop *et al.*, 2007). However, from the clinical point of view, it is advised to use Reverse Pull Face Mask 14-16 hours per day (Yepes *et al.*, 2014).

The aim of Reverse Pull Face Mask therapy is forward displacement of the maxilla with downward-backward rotation of the mandible and maxillary teeth proclination along with retroclination of mandibular teeth. If the direction of elastic traction is slightly downwards, a downward-forward movement of the maxilla along with downward-backward rotation of the mandible is achieved. However, this downward direction of force is only applicable in children with normal or reduced lower facial height, as it increases the lower facial height (Proffit *et al.*, 2007).

2.9 Reverse Twin-Block Appliance

Reverse Twin-Block is an intra-oral orthodontic appliance consisting of upper and lower bite blocks. This functional appliance was originally designed by W. J. Clark for full-time wear (Clark, 1997b). This appliance contains inclined bite planes 70° towards the occlusal plane. This inclined bite plane transmits the occlusal force through the dentition to the underlying trabecular structure of the supporting bone and provides a continuous proprioceptive stimulus that influences the rate and direction of growth. RME was

incorporated with Reverse Twin-Block in case of maxillary constriction for three-way expansion . An expansion screw was incorporated in the upper block for RME and labial bow in both upper and lower blocks to control excessive proclination. Adams clasp and ball clasps were added for anchorage .

Although, the mechanism of functional appliances is quite different from the orthopedic appliances, the treatment effects are quite similar. They are also designed for forward-downward displacement of the maxilla, downward-backward rotation of the mandible, proclination of maxillary dentition along with retroclination of mandibular teeth (Proffit *et al.*, 2007). Without using any orthopedic or traction forces Reverse Twin-Block is capable of full functional correction of occlusal relationships. The masticatory forces are the most active force transmitted through the masticatory muscles involving the whole face and part of the cranium. When the patient eats with the appliance in mouth, a series of events take place. The design of appliance keeps the bite slightly open and the only contact is placed on the inclined bite planes. Then the patient bites down the appliance which drives the maxilla in a forward direction. The full masticatory force acts as corrective force for dento-facial development and produces maximum functional response to treatment. The masticatory force stimulates the sensory receptors of masticatory muscles, teeth and surrounding tissues and produces a functional response in the underlying bones. This functional response then supports the altered balance of masticatory force and corrects the maxillomandibular relationship (Clark, 1997a). Early management of developing Class III malocclusion was done successfully by Reverse Twin-Block appliance, however, the treatment effect was mostly dental rather than skeletal (Mittal *et al.*, 2017; Seehra *et al.*, 2012).

2.10 Lateral Cephalogram

Lateral cephalogram has been used by the orthodontists for more than seven decades. It is the primary diagnostic tool for orthodontics and dento-facial orthopedics. Diagnosis, treatment progress, post-treatment evaluation, research; it is used for all purposes (Yitschaky *et al.*, 2011). This radiograph provides a two-dimensional lateral view of the skull highlighting the hard and soft tissue features. With the evaluation of modern three-dimensional diagnostic tools, the use of this conventional two-dimensional tool is being questioned. A tendency has developed to use the three-dimensional imaging routinely in orthodontic treatment planning, without any clear clinical reason (Silva *et al.*, 2008). It is supposed that three-dimensional tools produce clearer and more accurate image than two-dimensional tools. However, some studies compared the measurements produced by both lateral cephalogram and cone-beam computed tomography (CBCT)/computed tomography (CT) (Vizzotto *et al.*, 2012; Yitschaky *et al.*, 2011). In case of hard tissue, the angular and ratio measurements are found to be similar and the average difference of linear measurement was about 0.5mm, which was not clinically significant (Yitschaky *et al.*, 2011). For pharyngeal airway evaluation, lateral cephalometry has found to be reliable (Major *et al.*, 2006; Mislik *et al.*, 2014). In comparison to CBCT, a positive correlation was found in airway linear measurements by lateral cephalometry (Vizzotto *et al.*, 2012).

Considering the radiation exposure, the use of three-dimensional image is not recommended for routine orthodontic practice. From this point of view, a conventional two-dimensional image produces much lower radiation and it is safe to use in routine

orthodontic practice (Silva *et al.*, 2008). It is obvious that, conventional two-dimensional diagnostic tools are much cheaper and more available than three-dimensional tools.

CHAPTER THREE

OBJECTIVES OF THE STUDY

3.1 General Objective

To evaluate and compare the treatment effects of Reverse Twin-Block and Reverse Pull Face Mask appliance for Class III malocclusion in Malay children.

3.2 Specific Objectives

i. To evaluate dento-facial changes by Reverse Twin-Block and Reverse Pull Face Mask appliance therapy based on pre and post-treatment lateral cephalograms.

ii. To compare dento-facial changes by Reverse Twin-Block and Reverse Pull Face Mask appliance therapy based on pre and post-treatment lateral cephalograms.

iii. To compare dento-facial changes between early and late mixed dentition stages for Reverse Twin-Block and Reverse Pull Face Mask appliance therapy based on pre and post-treatment lateral cephalograms.

iv. To compare dento-facial changes between male and female children for Reverse Twin-Block and Reverse Pull Face Mask appliance therapy based on pre and post-treatment lateral cephalograms.

3.3 Research Question

i. What are the treatment changes on the dento-facial morphology of Class III malocclusion by Reverse Twin-Block and Reverse Pull Face Mask appliance?

ii. Which orthodontic appliance shows better efficacy in the treatment of Class III malocclusion among Reverse Twin-Block and Reverse Pull Face Mask appliance?

iii. Is there any difference in the treatment outcome of Reverse Twin-Block and Reverse Pull Face Mask appliance between early and late mixed dentition groups?

iv. Is there any difference in the treatment outcome of Reverse Twin-Block and Reverse Pull Face Mask appliance between male and female children?

3.4 Alternative Hypothesis

i. There is a significant improvement in the dento-facial morphology of growing Class III patients after treatment with either Reverse Twin-Block or Reverse Pull Face Mask appliance based on pre and post-treatment lateral cephalograms.

ii. There is a significant difference between the treatment effects of Reverse Twin-Block and Reverse Pull Face Mask appliance based on pre and post-treatment lateral cephalograms.

iii. There is a significant difference between the treatment effects of early and late mixed dentition groups under Reverse Twin-Block and Reverse Pull Face Mask appliance based on pre and post-treatment lateral cephalograms.

iv. There is a significant difference between the treatment effects of male and female children under Reverse Twin-Block and Reverse Pull Face Mask appliance based on pre and post-treatment lateral cephalograms.

CHAPTER FOUR

MATERIALS AND METHODS

4.1 Study Design

This cross-sectional study was performed to evaluate and compare the treatment effects of Reverse Twin-Block and Reverse Pull Face Mask appliance on mixed dentition Malay children with Class III malocclusion. The subjects were divided into two groups; one group was treated with Reverse Twin-Block and the other group was treated with Reverse Pull Face Mask appliance. The evaluation and comparison were based on pre- and post-treatment lateral cephalometric measurements. The pre- and post-treatment lateral cephalograms were obtained retrospectively from the archive of HUSM (Hospital Universiti Sains Malaysia) with permission.

This study was conducted in the School of Dental Sciences, Universiti Sains Malaysia, Kubang Kerian, Kelantan, Malaysia from March 2015 to August 2017.

4.2 Population and Sample

4.2.1 Reference Population: Malay children in Kubang Kerian area.

4.2.2 Source Population: The samples were obtained from HUSM archive with permission.

4.3 Sampling Frame

4.3.1 Inclusion Criteria

i. Overjet less than 0mm, between -1 to -5mm.

ii. Class III deciduous canine relationship and/or Class III molar relationship.

iii. Malay ethnicity.

iv. Patients aged from 8-9 and 10-11 years.

v. A clear image of pre- and post-treatment lateral cephalograms.

4.3.2 Exclusion Criteria

i. Children with craniofacial anomalies.

ii. Previous orthodontic appliance therapy.

iii. History of facial trauma.

iv. Cephalograms that are blur.

4.3.3 Sample Size Calculation

This comparative cross-sectional study was designed to evaluate and compare between pre- and post-treatment lateral cephalograms of growing Class III malocclusion Malay children either treated with Reverse Twin-Block or Reverse Pull Face Mask appliance. The sample size calculation was performed by Tabachnik and Fidell formula; N>50+8m, where m=number of independent variables (Tabachnick and Fidell, 2013). With three independent variables- age, gender and type of appliance; minimum 74 samples were required. The final sample size was 95, where 49 patients were in Reverse Twin-Block group and 46 patients were in Reverse Pull Face Mask group.

4.3.4 Sampling Method

The samples were selected from a previously conducted randomized clinical trial in School of Dental Sciences, Universiti Sains Malaysia based on the selection criteria (Mohammed *et al.*, 2014). The pre- and post-treatment lateral cephalograms were gathered from HUSM archive with permission based upon the inclusion and exclusion

criteria. Malay ethnicity of the samples were confirmed in the previous study assuring there was no inter-racial marriage up to three generations in both paternal and maternal side of the child. Parents of the children and school record confirmed this information. Age was confirmed from school records. Incisor and molar relationships were assessed during primary screening and children having overjet from -1mm to -5mm were included in the study. To randomize the subjects into Reverse Twin-Block and Reverse Pull Face Mask group coin toss method was performed in the previous study (Mohammed *et al.*, 2014).

4.4 Age of Sample

The samples were subdivided into two age groups ranging from 8-9 years and 10-11 years. Both appliance groups contained samples from these two age groups. Reverse Twin-Block group had 24 samples of early and 25 samples of late mixed dentition stage. Whereas, Reverse Pull Face Mask group had 20 samples of early and 26 samples of late mixed dentition stages.

4.4.1 Early Mixed Dentition Stage (8-9 years): Erupting permanent incisors and first permanent molars.

4.4.2 Late Mixed Dentition Stage (10-11 years): Erupting permanent canines and premolars.

4.5 Ethical Approval

This study was approved by the Human Research Ethics Committee (HREC) of Universiti Sains Malaysia and was in accordance with the approved guidelines. The code for ethical approval from the Jawatankuasa Etika Penyelidikan Manusia Universiti Sains Malaysia (JEPeM-USM) is **USM/JEPeM/15070240**.

4.6 Research Tools

4.6.1 Armamentarium

i. Both hard and soft copies of 190 pre- and post-treatment lateral cephalograms.

ii. VIDAR's DiagnosticPRO® Advantage film digitizer (USA) for scanning and digitization of the lateral cephalograms (Figure 4.1).

iii. HP 2000 Notebook PC.

Figure 4.1 VIDAR's DiagnosticPRO® Advantage film digitizer

4.6.2 Software for Cephalometric Measurements

i. Computer-Assisted Simulation System for Orthognathic Surgery (CASSOS 2001, Hong Kong) software.

ii. The Medical Imaging Interaction Toolkit (MITK 3M3) software, Version 1.1.0.

4.6.3 Software for Statistical Analysis

i. Statistical Package for the Social Sciences (SPSS) for Windows, Version 22.0 (IBM Corp., Armonk, NY, USA).

4.7 Details of Orthodontic Appliances

Two orthodontic appliances, Reverse Twin-Block and Reverse Pull Face Mask were used for treatment of Class III malocclusion.