

**THE STUDY OF EARLY ORTHODONTIC
SCREENING AND REFERRAL PRACTICES BY
DENTAL THERAPISTS IN MALAYSIA**

LIM YEN NIE

UNIVERSITI SAINS MALAYSIA

2024

**THE STUDY OF EARLY ORTHODONTIC
SCREENING AND REFERRAL PRACTICES BY
DENTAL THERAPISTS IN MALAYSIA**

by

LIM YEN NIE

**Thesis submitted in fulfilment of the requirements
for the degree of
Master of Science**

March 2024

ACKNOWLEDGEMENT

First, I would like to express my gratitude to Dr. Fadzlinda Baharin, my supervisor, for being the source of inspiration for this work. Dr. Fadzlinda has assisted and guided me during the entire study process. I like her sense of humour when times are tough and her checking in with me to ensure the research progresses well. Next, I want to thank my co-supervisor, Professor Dr. Rozita Hassan, an orthodontic specialist who contributed advice and professional input during my thesis composition. The research team members who provided constructive ideas for this survey will be remembered. I thank Dr. Noormi binti Othman, principal director of the Oral Health Program, Ministry of Health Malaysia, for approving this research. I want to thank the dental therapists for their resounding responses. Their feedback has been invaluable and greatly appreciated. Not to be overlooked are the Health System Research (HSR) state coordinators and senior dental officers of 15 divisions for their effective collaboration in providing dental therapists' data and distributing the questionnaires. Lastly, I would like to thank my mother, Madam Oh Kim Peng, who has always loved and supported me unconditionally. I appreciate my partner, Andrew Tee, for his encouragement to take one step at a time and to trust God. I am thankful to Miss Poh, Dr. Tee, and Mrs. Tee for their support, providing me with the necessary space for my thesis write-up, and ensuring I am well-fed with nutritious meals. "I learned that courage was not the absence of fear, but the triumph over it. The brave man is not he who does not feel afraid, but he who conquers that fear.", said Nelson Mandela. I wouldn't hold myself in the same regard as Nelson Mandela. Yet, I commend myself for braving research and writing, activities once daunting. The unwavering support from those alongside me in my master's journey makes it all possible.

TABLE OF CONTENTS

ACKNOWLEDGEMENT	ii
TABLE OF CONTENTS	iii
LIST OF TABLES	vii
LIST OF FIGURES	viii
LIST OF ABBREVIATIONS	x
LIST OF APPENDICES	xi
ABSTRAK	xii
ABSTRACT	xiv
CHAPTER 1 INTRODUCTION	1
1.1 Background of the study.....	1
1.2 Problem statement	3
1.3 Justification of study	4
1.4 Conceptual Framework	5
1.5 Research question.....	6
1.6 Research hypothesis	6
1.7 Objectives	7
1.7.1 General objective	7
1.7.2 Specific objectives	7
CHAPTER 2 LITERATURE REVIEW	8
2.1 Establishment of dental therapists	8
2.2 Primary oral healthcare systems in other countries.....	9
2.3 History of dental therapists in Malaysia.....	10
2.3.1 Primary oral healthcare system in Malaysia: A focus on incremental dental care system	11
2.3.2 Accomplishments and contributions of dental therapists in SDS	12
2.3.3 Role of dental therapists in orthodontic care.....	12
2.3.4 The challenges and obstacles of early orthodontic screening and referral practices in SDS	13
2.4 Malocclusion	14

2.4.1	Prevalence of malocclusion.....	14
2.4.2	Definition of malocclusion.....	16
2.4.3	Aetiology of malocclusion	16
2.4.4	Complication of malocclusion	18
2.5	Early interceptive orthodontics	21
2.5.1	Timing of orthodontic treatment	22
2.6	The prevalence of orthodontic screening by dental therapists	24
2.6.1	Clinical conditions assessed during orthodontic screening.....	26
2.6.2	Additional diagnostic tools in orthodontic screening	27
2.6.3	Usage of guidelines in orthodontic screening	27
2.7	The prevalence of orthodontic referral by dental therapists.....	29
2.7.1	Orthodontic referral documents	30
2.7.2	Orthodontic referral consultation	30
2.7.3	Self-aassessment of the dental therapists' effectiveness and confidence in orthodontic referrals	31
2.7.4	Appropriateness of orthodontic referral by general dental practitioners.....	32
2.8	The association between the socio-demographic profile and the training of dental therapists.....	33
2.9	The perception of dental therapists towards orthodontic treatment	35
2.10	Co-occurrence frequencies between orthodontic screening, referral practice and demographic profile of the dental therapists	36
2.11	Conclusion.....	37
	CHAPTER 3 MATERIALS AND METHOD	38
3.1	Research design	38
3.2	Sample size estimation	39
3.2.1	Objective 1	39
3.2.2	Objective 2	39
3.2.3	Objective 3	40
3.2.4	Objective 4	41
3.2.5	Final sample size	41
3.3	Sampling method.....	42

3.4	Research tool	44
3.5	Data collection method.....	45
3.6	Data analysis.....	49
3.7	Consent and ethical approval.....	50
CHAPTER 4 RESULTS		51
4.1	Socio-demographic profile of respondents.....	51
4.2	Prevalence of orthodontic screening practice.....	52
4.2.1	Prevalence of orthodontic screening routine.....	52
4.2.2	Prevalence of orthodontic screening assessment	52
4.2.3	Prevalence of additional diagnostic tools in orthodontic screening	53
4.2.4	Prevalence of usage of guidelines in orthodontic screening	54
4.3	Prevalence of orthodontic referral practice	55
4.3.1	Prevalence of average number of orthodontic referrals	55
4.3.2	Prevalence of orthodontic referral documents	55
4.3.3	Prevalence of orthodontic referral consultation	56
4.3.4	Self-assessment of the dental therapists' effectiveness and confidence in orthodontic referrals	57
4.4	The association between the prevalence of orthodontic referral practice and the training of dental therapists	59
4.4.1	Association of the average orthodontic referral number and exposure to orthodontic theory	60
4.4.2	Association of the average orthodontic referral number and exposure to the orthodontic practice	61
4.4.3	Association of the average orthodontic referral number and exposure to orthodontic diagnosis.....	61
4.4.4	Association of the average orthodontic referral number and the case discussion partner	62
4.5	The view of dental therapists on orthodontic treatment	63
4.5.1	Opinion of orthodontic as a treatment priority.....	63
4.5.2	Opinion of orthodontic screening and referral process	64
4.6	Co-occurrence network analysis of orthodontic screening, referral practices and socio-demographic profile.....	65

CHAPTER 5	DISCUSSION.....	67
5.1	Introduction	67
5.2	Socio-demographic profile	68
5.3	Orthodontic screening practice.....	71
5.4	Orthodontic referral practice	75
5.5	The association between the prevalence of orthodontic referral practice and the training of dental therapists	78
5.6	The view of dental therapists on orthodontic treatment	80
5.7	Co-occurrence network analysis on orthodontic screening, referral practices and socio-demographic profile.....	82
CHAPTER 6	CONCLUSION AND FUTURE RECOMMENDATIONS	84
6.1	Conclusion.....	84
6.2	Limitations of the study.....	85
6.3	Implications to the dental healthcare service.....	86
6.4	Recommendations for future studies	86
REFERENCES	88
APPENDICES		
LIST OF PUBLICATION		

LIST OF TABLES

		Page
Table 3.1	Population size of each stratum.....	42
Table 3.2	Sample size of each stratum.....	43
Table 4.1	Socio-demographic of respondents (<i>n</i> =352).....	51
Table 4.2	Prevalence of orthodontic screening routine (<i>n</i> =352).....	52
Table 4.3	Prevalence of orthodontic screening assessment (<i>n</i> =237)	53
Table 4.4	Prevalence of additional diagnostic tools (<i>n</i> =237).....	54
Table 4.5	Prevalence of usage of guideline in orthodontic screening (<i>n</i> =237)..	54
Table 4.6	Prevalence of average number of orthodontic referrals per month (<i>n</i> =352).....	55
Table 4.7	Prevalence of orthodontic referral documents (<i>n</i> =267)	56
Table 4.8	Prevalence of orthodontic referral consultation (<i>n</i> =267)	56
Table 4.9	Prevalence on offering brief information about treatment options prior to orthodontic referral (<i>n</i> =267).....	56
Table 4.10	Self-evaluation of effectiveness of orthodontic referrals (<i>n</i> =267).....	57
Table 4.11	Criticisms received from self-assessed ineffective orthodontic referral (<i>n</i> =2)	58
Table 4.12	Prevalence of self-assessed confidence level on orthodontic referrals (<i>n</i> =258)	59
Table 4.13	The association of average orthodontic referral number and the exposure to orthodontic theory (<i>n</i> =352).....	60
Table 4.14	The association of the average orthodontic referral number and the exposure to orthodontic practice (<i>n</i> =352)	61
Table 4.15	The association of the average orthodontic referral number and the exposure to orthodontic diagnosis (<i>n</i> =352).....	62
Table 4.16	The association of the average orthodontic referral number and the case discussion partner (<i>n</i> =352).....	63
Table 4.17	Prevalence of opinion of orthodontics as treatment priority (<i>n</i> =352)	64
Table 4.18	Prevalence of opinion of orthodontic screening and referral process (<i>n</i> =352).....	64

LIST OF FIGURES

	Page
Figure 1.1	Conceptual framework of study 5
Figure 3.1	Calculation of sample size for the association between two variables 40
Figure 3.2	Flowchart of study 48
Figure 4.1	Co-occurrence frequency of socio-demographic profile and orthodontic screening and referral practice 66

LIST OF SYMBOLS

=	Equal sign
>	Greater than
<	Less than
%	Percentage
Δ	Precision
Z	Z-score is a statistical measurement that describes a value's relationship to the mean of a group of values.
P	Expected prevalence in single proportion formula
n	Sample size
p	P-value
r_s	Spearman correlation coefficient

LIST OF ABBREVIATIONS

HSR	Health System Research
AAO	American Association of Orthodontists
MOH	Ministry of Health
SDS	School Dental Service
IOTN	Index of Orthodontic Treatment Need
WHO	World Health Organization
IBM SPSS	Statistical Package for the Social Sciences
CPD	Continuing professional development
TMJ	Temporomandibular joint
TMD	Temporomandibular disorder
OSA	Obstructive sleep apnea
OSAS	Obstructive sleep apnea syndrome
DMFT	Decayed, missing and filled teeth
GDP	General dental practitioner
AC	Aesthetic component
DHC	Dental health component
SDO	Senior dental officer
CD	Compact disc

LIST OF APPENDICES

Appendix A	Orthodontic referral form from primary care dental clinic to specialist clinic
Appendix B	Krejcie and Morgan table
Appendix C	Questionnaire in google form
Appendix D	Permission to use the questionnaire tool
Appendix E	Content and linguistic validity form
Appendix F	Photograph with the policymakers of the Oral Health Programme (MOH)
Appendix G	Original version of questionnaire
Appendix H	WHO process of translation and adaptation of instruments
Appendix I	Translated and pre-tested questionnaire

**KAJIAN AMALAN SARINGAN DAN RUJUKAN AWAL ORTODONTIK
OLEH JURUTERAPI PERGIGIAN DI MALAYSIA**

ABSTRAK

Di Malaysia, terdapat keperluan rawatan ortodontik yang tinggi dalam kalangan murid sekolah. Keberkesanan rawatan ortodontik adalah bergantung pada waktu yang tepat rujukan kes-kes yang telah menjalani proses saringan. Juruterapi pergigian adalah antara orang yang pertama untuk mengenal pasti sebarang maloklusi dalam kalangan murid sekolah rendah Malaysia. Kajian ini bertujuan untuk menentukan frekuensi amalan saringan dan rujukan awal ortodontik oleh juruterapi pergigian dalam kalangan murid sekolah rendah. Kajian ini juga menentukan perkaitan antara amalan rujukan dan latihan juruterapi pergigian. Kajian keratan rentas ini telah dijalankan dalam kalangan 360 juruterapi pergigian di Malaysia. Soal selidik telah disesuaikan daripada kajian Lim *et al.* dan diterjemahkan ke dalam bahasa Melayu. Soal selidik ini telah diuji terlebih dahulu. Data-data berikut telah dikumpulkan menggunakan soal selidik secara dalam talian: (1) profil sosio-demografi, (2) amalan saringan dan rujukan awal ortodontik, (3) latihan juruterapi pergigian, dan (4) pandangan rawatan ortodontik. Pengambilan sampel rawak berstrata telah dilakukan. Analisis deskriptif dan analisis bivariat (*Fisher's Exact Test and Spearman correlation*) telah dijalankan ke atas data yang telah terkumpul dengan menggunakan IBM SPSS (versi 26). Selain itu, SPSS Modeler (versi 18.0.0) telah digunakan untuk meneroka secara visual tentang frekuensi keselarian bersama antara pemboleh ubah melalui graf web. Kajian ini mendapat kadar respons sebanyak 97.8% ($n=352$). Kajian ini mendapati bahawa kurang daripada satu perempat daripada juruterapi pergigian (22.7%) melakukan penyaringan ortodontik pada semua kanak-kanak sekolah rendah, dan hampir satu pertiga (32.7%) juruterapi pergigian tidak melakukan penyaringan

ortodontik secara rutin. Penilaian ortodontik yang biasa dilakukan semasa saringan ortodontik adalah *overjet* (92.8%), kehadiran jarak atau sesak gigi (92.4%), *overbite* (86.9%) dan kehadiran *crossbite* (78.9%). Hampir separuh daripada juruterapi pergigian (47.7%) lebih suka mendapatkan nasihat doktor gigi semasa saringan daripada menggunakan garis panduan (32.9%). Lebih separuh daripada mereka (65.6%) merujuk kurang daripada lima pesakit sebulan, manakala hampir satu perempat (24.1%) tidak merujuk pesakit. Juruterapi pergigian menggunakan pelbagai dokumen rujukan. Bilangan rujukan pesakit setiap bulan dikaitkan dengan pendedahan kepada teori ortodontik, latihan ortodontik dan pengalaman dengan diagnosis ortodontik dalam kerjaya mereka. Kesimpulannya, kajian ini memperoleh kadar respons yang tinggi. Kadar penyaringan ortodontik juruterapi pergigian adalah rendah dalam kalangan semua kanak-kanak sekolah rendah. Kepelbagaian dokumen rujukan telah dikenal pasti. Borang rujukan piawai dari sekolah ke klinik pergigian primer disyorkan untuk memastikan pemantauan dan rawatan tepat pada masa bagi kes yang didiagnosis. Kakitangan kesihatan mulut yang terlibat dalam perkhidmatan pergigian kanak-kanak sekolah sangat digalakkan menggunakan proforma dalam saringan ortodontik dan menyertai kursus pembangunan profesional berterusan (CPD).

THE STUDY OF EARLY ORTHODONTIC SCREENING AND REFERRAL PRACTICES BY DENTAL THERAPISTS IN MALAYSIA

ABSTRACT

In Malaysia, the orthodontic treatment needs of schoolchildren are high. Effective orthodontic treatment delivery depends on timely referrals of cases that have undergone an appropriate screening process. Dental therapists are among the first to identify any malocclusion in Malaysian primary schoolchildren. This study aimed to determine the prevalence of early orthodontic screening and referral practices by dental therapists among primary schoolchildren. The association between dental therapists' referral practice and the training of dental therapists were determined. A cross-sectional study was conducted among 360 dental therapists in Malaysia. The questionnaire tool was adapted from the study of Lim et al. and translated into Malay. The adapted and translated questionnaire was pre-tested. The following variables were gathered using an online self-administered questionnaire: (1) the socio-demographic profile, (2) orthodontic screening and referral practices, (3) training of dental therapists, and (4) views on orthodontic treatment. A stratified random sampling was done. Descriptive analysis and bivariate analysis (Fisher's Exact Test and Spearman correlation) were conducted on collected data using IBM SPSS (version 26). In addition, SPSS Modeler (version 18.0.0) was used to visually explore the co-occurrence frequency of the variables via the web graphs. This survey obtained a response rate of 97.8% (n=352). The study revealed that less than one-quarter of the dental therapists (22.7%) performed orthodontic screening on all primary schoolchildren, and almost one-third (32.7%) did not routinely do orthodontic screening. The common orthodontic assessment done during the orthodontic screening was overjet (92.8%), the presence of spacing or crowding (92.4%), overbite (86.9%)

and the presence of crossbite (78.9%). Almost half of the dental therapists (47.7%) preferred dentists' advice during screening instead of using guidelines (32.9%). More than half of them (65.6%) referred less than five patients per month, while almost one-quarter (24.1%) did not refer patients. Dental therapists used a variety of referral documents. The average orthodontic referral number is associated with exposure to orthodontic theory, practice and experience with orthodontic diagnosis during their career. In conclusion, this study obtained a high response rate. The orthodontic screening rate of dental therapists in all primary schoolchildren is poor. Variation in referral documents is identified. A standardized referral form from the school to the primary dental clinic is recommended to ensure timely monitoring and treatment of diagnosed cases. Oral health personnel working with schoolchildren are strongly encouraged to use a proforma in orthodontic screening and participate in continuing professional development (CPD).

CHAPTER 1

INTRODUCTION

1.1 Background of the study

Globally, the malocclusion prevalence among children and adolescents is 56% (Lombardo et al., 2020), with the highest prevalence in Africa (81%) and the lowest prevalence in Asia (48%). The global distribution of Class I, II, and III malocclusions in mixed dentition was 73%, 23%, and 4% (Sultan et al., 2018). In Malaysia, a study was conducted among schoolchildren to evaluate the orthodontic treatment need and demand for better orthodontic service planning. The study revealed that over half (51.4%) of 12-year-old schoolchildren had a definite need for treatment ($DHC > 4$), and 22% of them desired the treatment. The study concluded that Malay schoolchildren have significant orthodontic treatment needs (Zreaqat et al., 2013).

Another Malaysian study (Elfseyie et al., 2020) on malocclusion prevalence was conducted among Malay adults, revealing that the incidence of Class III was higher in the Malay population. The study urged the clinicians to promote preventive and interceptive treatment in Malay population. The earlier systematic review recommended that the global malocclusion rates and its onset during childhood should prompt policymakers, paediatrics specialists, and dentists to develop policies and implement clinical strategies to prevent or reduce malocclusion in younger children (Lombardo et al., 2020).

The American Association of Orthodontists (AAO) recommend that children should have their orthodontic screening with orthodontists by the age of 7. Early orthodontic interventions usually commence during the developing dentition stage to promote

favourable developmental changes and eliminate or stop unfavourable ones (Wong et al., 2004). As recommended in the official portal of the Ministry of Health (MOH) Malaysia, the right time to perform interceptive orthodontics is in mixed dentition for children aged from 6 to 12 years old (Khalil, 2020).

Interceptive orthodontics treatment for growing children aims “to prevent or minimise dental development abnormalities while enabling craniofacial growth modification” and “entails monitoring for a variety of conditions, including excessive space, severe crowding, open or deep bites, anterior and posterior crossbites, severe overjet, and abnormal eruption patterns” (Mostafiz, 2019). Early detection and appropriate referral of children who require interceptive orthodontics are important (Elfseyie et al., 2020, Wong et al., 2004).

The MOH Malaysia (*Oral Healthcare for School Children in Malaysia*, 2006) has delivered oral healthcare to primary and secondary schoolchildren through the School Dental Service (SDS) to ensure they achieve oral fit status before they leave school. According to data in the official Oral Health Program, MOH portal, the coverage of dental outreach among primary schoolchildren in Malaysia was almost 98.2% in 2009 (*School Dental Service*, 2022). Since 1985, SDS is provided by dental therapists to schoolchildren, particularly in primary schools. Dental therapists will then refer the primary schoolchildren requiring treatment beyond their competency and scope of practice to dental officers in clinics.

The dental therapists among the first person to detect any form of malocclusion among primary schoolchildren. Dental therapists are expected to be well-versed in orthodontic screening to prevent any inappropriate referral or delayed orthodontic treatment after the children have reached adolescence. Notably, scarce studies are conducted to

investigate the orthodontic screening and referral practices of dental therapists (Lim et al., 2017, Tan et al., 2016, Tsai and Nawi, 2020). Currently, one pilot study (Tsai and Nawi, 2020) was conducted in Kuching, Sarawak, on orthodontic screening and referral practices by dental therapists among primary schoolchildren.

Hence, this study aims to determine Malaysian dental therapists' early orthodontic screening and referral practices among primary schoolchildren. This study will serve as baseline data for documentation purposes and planning impactful future studies under the direction of the Oral Health Program of MOH.

1.2 Problem statement

Orthodontic issues in children can have a lasting impact on their oral health and overall well-being. A local research study conducted in Malaysia, as reported by Zreaqat et al. in 2013, indicated a notable demand for orthodontic treatment among schoolchildren. This demand primarily stems from dental issues such as increased overjet, crowding, and deep overbites. According to the report, 93.0% of secondary school students in the region had malocclusion. Class I malocclusion accounted for most cases, with 80%, followed by class II (8%) and class III (12%). The most common occlusal abnormalities among primary schoolchildren were dental crowding, increased or reduced overjet, and reversed overjet. In the case of children and early adolescents, if these malocclusions persist without treatment, they can potentially lead to adverse psychological and social consequences, significantly impacting the individual's quality of life. Notably, a strong correlation has been observed between schoolchildren exhibiting a Class II Division 1 incisor relationship and their susceptibility to bullying.

Therefore, timely identification and intervention are essential for successful orthodontic treatment.

1.3 Justification of study

The optimal window for implementing interceptive orthodontics falls within the mixed dentition phase, typically spanning from 6 to 12 years of age, as underscored by Khalil in 2020. Early intervention in the form of interceptive orthodontics can simplify the subsequent orthodontic treatment, reducing both the time and cost associated with the overall treatment process. In Malaysia, dental therapists play a significant role in delivering primary oral healthcare to schoolchildren, including the opportunity to screen and refer orthodontic cases. However, there is limited empirical data available on the consistency and comprehensiveness of these practices. Hence, this study aims to investigate the prevalence of early orthodontic screening and referral practices among dental therapists across different regions of Malaysia and assess the factors that may influence their decisions to refer schoolchildren for orthodontic evaluation.

1.4 Conceptual Framework

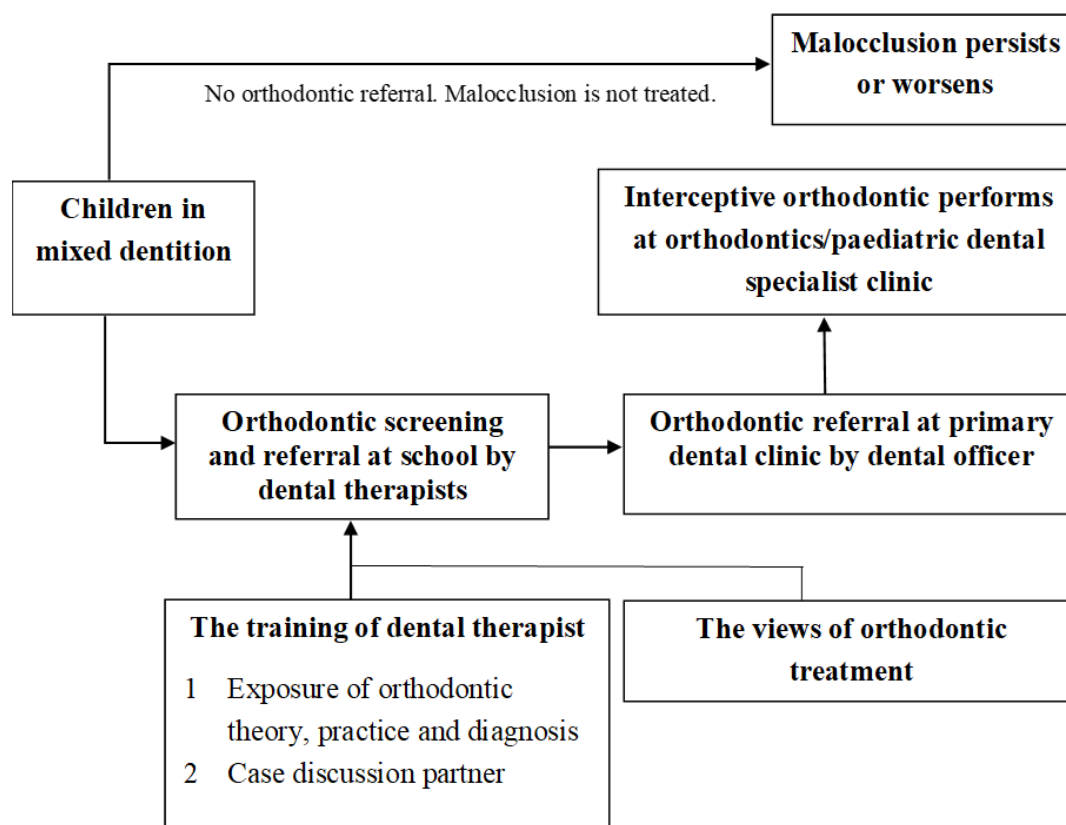


Figure 1.1 Conceptual framework of study

Figure 1.1 illustrates the conceptual framework of the study by showing the process of dental therapists' early orthodontic screening and referral practices. During SDS, the dental therapists who perform orthodontic screening will identify the children with malocclusion that requires interceptive orthodontic treatment. The children who need orthodontic treatment will be referred from school to a dental officer in the primary dental clinic for further examination. The training of dental therapists and their views of orthodontic treatment may affect their orthodontic screening and referral practices, including (1) exposure to orthodontic theory, practice and diagnosis and (2) case discussion partner. The dental officer in the primary dental clinic will refer the children who fulfil the Index of Orthodontic Treatment Need (IOTN) grade 4 or 5 to the orthodontic or paediatric dental specialist clinic for orthodontics treatment. With

interceptive orthodontics, the complexity of the malocclusion can be reduced or even eliminated.

On the other hand, if there were no orthodontic screening and referral by dental therapists at school, the mixed-dentition children with malocclusion would not be treated or receive any orthodontic treatment. The malocclusion will persist as it will not resolve spontaneously or even worsen.

1.5 Research question

This framework is designed to answer the research question: “Do dental therapists perform orthodontic screening and referral practices among primary schoolchildren, and how does the training of dental therapists affect the referral practice?”.

1.6 Research hypothesis

1. There is high prevalence of orthodontic screening and referral practice among primary schoolchildren by dental therapists in Malaysia.
2. There is an association between the orthodontic referral practice and the training of dental therapists.

1.7 Objectives

The general objective and specific objectives of the study are listed below.

1.7.1 General objective

To study the implementation of early orthodontic screening and referral practices among primary schoolchildren by dental therapists in Malaysia.

1.7.2 Specific objectives

- a) To determine the prevalence of orthodontic screening practice among primary schoolchildren by dental therapists in Malaysia.
- b) To determine the prevalence of orthodontic referral practice among primary schoolchildren by dental therapists in Malaysia.
- c) To determine the association between the orthodontic referral practice and the training of dental therapists.
- d) To determine the view of dental therapists towards orthodontic treatment.
- e) To obtain a graphical co-occurrence network between orthodontic screening, referral practice and demographic profile of the dental therapists.

CHAPTER 2

LITERATURE REVIEW

2.1 Establishment of dental therapists

The dental therapist was first developed and introduced in New Zealand. Many young men and women were rejected for military service during World War I due to rampant dental diseases (Friedman, 2011). The poor state of oral health was attributed by many to the negligence of oral health in childhood (Tennant, 1991). The ratio of dentists to population was 1:12,000, so it was impossible to deliver dental care effectively.

In 1920, the New Zealand Department of Health established the first training school for dental nurses, which is now called Dental Therapists, based in Wellington. The dental therapists were trained to deliver dental care to the children. Under the influence of stereotypical perception, it was believed that women were "temperamentally and psychologically more suited than men to deal with and treat the ailments of very young children" (Moffat et al., 2017). After two years of training, the dental therapists were assigned to serve in public school dental services and community clinics (Nash et al., 2014).

In the early days, dental therapists were trained to perform basic dental treatment, including dental prophylaxis, intra-coronal restorations and extraction of primary teeth (Nash et al., 2008). Later, they provided more extensive treatment, including placement of prefabricated stainless-steel crowns and vital pulp therapy on primary dentition (Nash et al., 2008). In the dental therapists' curricula, a strong emphasis was placed on oral health promotion and oral disease prevention (Nash et al., 2014).

In 1923, a compulsory SDS was established in elementary schools with 30 dental nurses under the indirect supervision of the district government dentists (Nash et al., 2008). The children that received SDS included pre-schoolers and children from 6 to 12 years old. The children aged between 13 and 16 were treated by private practising dentists paid by the government (Friedman, 2011).

Due to the lack of an oral health workforce, the other countries followed New Zealand's model. The dental therapists were initially trained in New Zealand, but later on, many countries established their training schools. A review paper (Nash et al., 2014) revealed that 54 countries used dental therapists as auxiliaries, mainly in school-based programs. The following countries were the early adopters of the dental therapists' model: Malaysia (1948), Sri Lanka (1949), Singapore (1950), Tanzania (1955) and the United Kingdom (1959). Five of the top six countries of the world that employed dental therapists were Australia, Netherlands, New Zealand, Canada and the United States (as of now, 13 states) (Mertz et al., 2021). Both developed and developing countries utilised dental therapists as auxiliaries, at least to a certain extent.

2.2 Primary oral healthcare systems in other countries

New Zealand is the pioneering country of SDS with the establishment of dental nurse (now called dental therapist) training school in 1920 (Saunders, 1964). Children in New Zealand from birth to 17 years old receive free primary oral healthcare services provided by dental therapists (*Publicly funded dental care*, 2019).

Our neighbouring country, Singapore, has utilised dental therapists since 1950 to provide primary oral care to children (Nash et al., 2014). In 2009, dental therapists at the dental service made 89% to 96% of elementary school students "dentally fit.". The

children aged 12 had DMFTs of 0.7, making Singapore one of the world's lowest DMFTs (Singapore, 2009). In Hong Kong, the Department of Health delivers primary oral healthcare to all primary schoolchildren through the School Dental Care Service. Dental therapists who work under the direct supervision of dental officers provide primary dental care to children.

Conversely, children in the United Kingdom under 18 years old receive free National Health Service dental services from a dentist (*Who is entitled to free NHS dental treatment in England?*, 2021) instead of an auxiliary nurse. In Finland, schoolchildren receive dental examinations at the local health centre's dental clinic every few years. Dentists perform the dental examinations during 1st, 5th and 8th grade (*Dental care*, 2022).

2.3 History of dental therapists in Malaysia

The first dental therapist training outside New Zealand was in Malaysia. In 1949, before the independence of the country Malaysia, The Malaysian Dental Training School was established and located in Penang. The dental therapists were called dental nurses in the community, where all the dental nurses were female and worked in the government sector (Nash et al., 2008).

Dr. Roy E. Anderson, the former Director of Malayan Medical Services, introduced New Zealand's model of the dental auxiliary. Mr. Anderson recounted what he discovered during his vacation in Wellington, New Zealand, to Mr. Charles F. Mummery, the former Chief Dental Officer of Malaya, regarding the dental nurses who were providing preventive and restorative treatment to the children (*History and development of children's dental center & malaysian dental training college*, 2022).

Coincidentally, Mr. Mummery was searching for solutions to improve the oral health facilities of children in Malaya, and he had been in communication with Mr. J. Llewellyn Saunders, the Director of New Zealand Dentistry at that time. The first batch of dental nurses completed the one-year training under the teaching of Miss K.B. Grumitt (dental sister tutor) by adapting the curriculum from New Zealand. Some dental nurses were sent to New Zealand to receive instructor training to increase the capacity of instructors in the Dental Training School.

2.3.1 Primary oral healthcare system in Malaysia: A focus on incremental dental care system

Since 1985, the Malaysian government has implemented the incremental dental care system in which dental therapists operate, which includes pre-school children from 5 to 6 years old and primary schoolchildren. Every district in a state has its own SDS team comprising dentists, dental therapists, dental surgical assistants, and dental attendants from public dental clinics (Ab Mumin et al., 2021). Secondary schoolchildren commonly receive oral healthcare services from dentists, while primary school students receive care from dental therapists. In addition, the SDS teams are in charge of other duties, such as annual dental examinations, treatments, and oral health promotion talks.

The systematic school dental healthcare was delivered through an incremental method emphasising the prevention, early detection and management of oral diseases. SDS is offered through school static clinics with more than 1000 students enrolled, while the mobile dental squad will serve schools with less than 1000 students (Othman and Razak, 2010). This initiative ensured that schoolchildren were deemed fit orally before leaving school (*Oral Healthcare for School Children in Malaysia*, 2006).

2.3.2 Accomplishments and contributions of dental therapists in SDS

According to the National Oral Health Survey of Schoolchildren, the caries prevalence in children aged 12 years old in the years 2017, 1997, and 1988 were 33.3%, 60.9% and 71.3%, respectively (*National Health and Morbidity Survey 2017: National Oral Health Survey of Schoolchildren 2017 (NHMS 2017)*, 2017). A study showed that the caries prevalence among 6-year-olds reduced from 95.4% in 1970 to 88.6% in 1988 (*Oral Healthcare for School Children in Malaysia*, 2006).

With the implementation of school-based incremental dental care, the statistics showed a decline in caries prevalence among schoolchildren. By 2005, the MOH had delivered oral healthcare to 92.5% of primary schoolchildren and 62.7% of secondary schoolchildren. Furthermore, in 2000, the Oral Health Division, MOH, organised a workshop on atraumatic restorative treatment (ART), making treatment more tolerable for pre-school children. The participants, including the dental officers and therapists, received ART training in parallel workshop sessions in local kindergartens (*Guidelines on Oral Healthcare for Preschool Children*, 2003).

The dental therapists and other auxiliary personnel annually provide dental health talks and teeth brushing drills during the two visits to designated kindergartens or preschools under the preschool oral healthcare programme. Dental therapists have made significant milestones in their field in the more than seven decades since they were first introduced. Over time, dental therapists have developed substantial expertise in identifying dental caries and have been recognized as proficient “caries busters”.

2.3.3 Role of dental therapists in orthodontic care

In orthodontic specialty of MOH Malaysia, most of the referral cases are received from primary dental clinics by dental officers and other specialist clinics. Dental therapists

play a vital role in performing orthodontic screening in primary schoolchildren during SDS. The schoolchildren with potential need of orthodontic treatment are referred to primary dental clinics for further examination by dental officers prior to referring them to orthodontic clinics for consultation.

Orthodontic treatment priority is given to children below 18 years old with malocclusion and the DHC of IOTN score of 4 and 5. Orthodontic referral form is available for the usage of dental officers to record the summary of the case and referring patients to orthodontics specialist clinic. However, no standardized form is available for the dental therapists to refer the children from school to primary dental clinics.

Moreover, the latest orthodontic referral guideline includes flowchart of referral from primary dental clinic, other orthodontic facilities and other specialist clinics (*Garis Panduan Rujukan Rawatan Ortodontik di Fasiliti Perkhidmatan Pergigian Kementerian Kesihatan Malaysia (KKM) [Guidelines for Orthodontic Treatment Referral at Dental Service Facilities of the Ministry of Health Malaysia]*, 2022). However, the guideline does not include a referral flowchart from a school setting. The common practice of dental therapists or dental officers in the SDS team is to verbally inform the child to ask their parents to bring them to the nearest primary dental clinic for further examination by the dental officers.

2.3.4 The challenges and obstacles of early orthodontic screening and referral practices in SDS

According to the local studies on SDS, many students expressed their dissatisfaction on the brief dental examination during SDS and there was minimal interaction between the SDS personnel and the students (Ab Mumin et al., 2021, Othman and Razak, 2010).

This finding may result from time constraints, as the SDS team faces a substantial workload and has limited manpower to cater to the needs of all government schools within coverage area (Ismail, 2002).

Under these conditions, it would be challenging for the dental therapists to conduct orthodontic screening in all primary school children during SDS. In addition, the dental therapists are lacking of orthodontic screening's skill as the exposure to orthodontic training during diploma is limited (*Program Latihan, 2023*). Comparatively, the dental therapists are well-versed and efficient in routine dental examination in identifying dental caries which has been proven by the continuing improvement in caries experience of among the schoolchildren in Malaysia with the lower caries prevalence and mean DMFT (*National Health and Morbidity Survey 2017: National Oral Health Survey of Schoolchildren 2017 (NHMS 2017)*, 2017).

2.4 Malocclusion

The literature review for the malocclusion subsection will encompass the subsequent subtopics: prevalence, definition, aetiology, and complications associated with malocclusion.

2.4.1 Prevalence of malocclusion

China, the world's largest population, is reported to have 47.92% of schoolchildren with malocclusion (Lin et al., 2020). For the Angle classification, the overall prevalence rates for Class I, Class II and Class III were 30.07% (95% CI: 25.37%-35.48%), 9.91% (95% CI: 7.41%-13.79%), and 4.76% (95% CI: 3.85%-6.54%) respectively. The study concluded that the findings showed that malocclusion is a

severe oral health issue among Chinese schoolchildren and highlighted the need for early intervention.

In India, a systematic review and meta-analysis were conducted to assess the prevalence of malocclusion among 8 to 15 years old Indian children using the Dental Aesthetic Index (DAI) or Angle's classification of malocclusion (Balachandran and Janakiram, 2021). The pooled prevalence of malocclusion among schoolchildren was 35.40% (CI:35.37–35.43, 54 studies, 97959 participants).

Iranian population showed a higher prevalence of malocclusion than China, where the prevalence for Class I, Class II and Class III was 54.6% (46.5–62.7), 24.7% (20.8–28.7), and 6.01% (4–7.1), respectively (Akbari et al., 2016). However, the included subjects were ranged from 3 to 18 years old. An epidemiology study in Northern Saudi Arabia revealed that the most common malocclusions of prevalence were Angle's Class I (52.8%), Angle's Class II (31.8%), Angle's Class III (15.4%) and crowding (47.2%) (Gudipaneni et al., 2018).

In Malaysia, a study (Mohd Azlan Sunil and Dhanraj, 2019) showed that 93.0% of the secondary schoolchildren in Malaysia had malocclusion, with 80% having Class I, 8% having Class II, and 12% having Class III malocclusion. Class II malocclusion was most common among the Indians (17.4%), whereas class III was more common in the Chinese (17.9%) and Malays (12.2%) populations. The most prevalent characteristic among the three ethnic groups was dental crowding (70%).

Another study was done among Malaysian primary schoolchildren to investigate the characteristics and association of gender with dental and occlusal anomalies (Zakaria et al., 2021). More than half of the children showed occlusal abnormalities of dental crowding (54.0%) and sagittal discrepancies (55.5%), including increased/reduced

overjet and reversed overjet. Similar to the earlier study, this study also concluded that dental crowding was the most common dental and occlusal anomaly in children with mixed and early permanent dentition.

2.4.2 Definition of malocclusion

The term “irregularities of the teeth” was commonly applied to express twisted or unevenly arranged teeth but did not fully express the meaning of these deformities. Angle proposed that the term “malocclusion” would be more expressive as it encompassed the relations of the dental arches and the individual teeth to one another. Malocclusion of the teeth would suggest occlusion’s supreme importance in managing these deformities.

The ideal occlusion depended on the position of the first molars. In normal occlusion, the mesiobuccal cusp of the upper first molar occluding with the buccal groove of the lower first molar, the buccal cusps of the lower premolars and molars contacting the mesiodistal sulci of their opposing teeth as a result of the upper teeth’s overhang, while the upper anterior teeth overlap the one-third crown length of the lower teeth (Angle, 1899).

According to Houston, malocclusion is a significant deviation from the ideal occlusion that may be deemed aesthetically unsatisfactory, suggesting an imbalanced condition in the relative teeth’ position and sizes, facial bones and soft tissues (i.e. cheek, lips and tongue) (WJB Houston, 1992).

2.4.3 Aetiology of malocclusion

According to the Handbook of Orthodontics (Cobourne and DiBiase, 2015), malocclusion should not be regarded as a single entity but a developmental condition. Malocclusion demonstrated multifactorial inheritance, which comprises a variety of

complex occlusal traits. In most cases, the aetiology is less obvious, though, in some instances, specific factors and pathologies could recognise the cause of malocclusion.

In a review paper by Proffit, he mentioned that in some instances, the cause of a specific malocclusion may be identified rather precisely. These specific causes may be allocated into four major groups:

1. Genetic syndromes
2. Defects of embryologic development
3. Trauma
4. Anomalies of postnatal development

Proffit's article showed a graph that illustrated that only a tiny proportion (5%) of all malocclusion could be attributed to one of these specific causes, and that left ten times (60%) as many people with orthodontic issues for whom there was no known explanation. As a result, these people must be classified as having non-specific or unknown aetiologies. In general, a genetic predisposition, an environmental effect that changed the ideal growth pattern, or a combination of the two were the causes of malocclusion of non-specific aetiologies (Proffit, 1986).

When both the jaws and dentition develop and grow, the genetics and the environment interact closely, and it is at this point the aetiology of malocclusion lies. In the past, malocclusion was thought to result from civilisation, and a stable treatment result would be achieved by re-establishing normal jaw function and occlusion.

In modern orthodontics, it was believed that hereditary factors caused malocclusion along with a better understanding of genetics, inheritance and the introduction of cephalometric radiography. As a result, cephalometric and clinical treatment goals were defined, frequently based on the mandibular incisor teeth's position. The

treatment focused on treating the malocclusion within the existing facial skeleton and soft tissue envelope.

In recent years, as research has moved away from Mendelian genetics, it has again turned its attention to the environmental factors contributing to malocclusion. Also, this has sparked a resurgence of interest in treatments that aim to modify jaw development (Cobourne and DiBiase, 2015).

2.4.4 Complication of malocclusion

Before adulthood, dental malocclusion in children and adolescents account for the majority of health-related expense (Smith, 1991). The long-term effects of dentoskeletal malocclusion include periodontal disease, dental decay, temporomandibular joint (TMJ) dysfunction, obstructive sleep apnea (OSA), psychological disorders secondary to poor face aesthetics and articulation error. In social aspect, bullying in school among children and adolescents is also associated to malocclusion.

The association between malocclusion and dental caries is more well-established than periodontal disease. Two recent systematic reviews reported that the lower DAI value was significantly associated with a lower mean DMFT index (Sá-Pinto et al., 2018, Singh and Purohit, 2021). One of the most prevalent malocclusion traits is dental crowding, which causes bacterial plaque to accumulate for an extended period and increases the frequency of dental caries (Gábris et al., 2006, Warren et al., 2003).

On the other hand, a study discovered the association between malocclusion and periodontal disease with two possible pathways. Firstly, the morphological traits associated with periodontal attachment loss include distal occlusion, increased overjet and overbite. Secondly, periodontal probing depth and attachment loss are elevated

due to the gingival margin being impinged upon by antagonistic teeth in a crossbite and deep overbite with contact with the gingiva. There is no clear link between occlusion and periodontal disease via incorrect tooth positioning, causing plaque build-up and periodontal breakdown (Bernhardt et al., 2019).

Temporomandibular disorders (TMDs), which are prevalent jaw problems, frequently include a variety of signs and symptoms, including discomfort in the TMJ or jaw muscles, unusual joint noises with mandibular movement, and limited mandibular movement (Egermark et al., 2003, Mohlin et al., 2004). An otorhinolaryngology surgeon, Costen, proposed the first historical account of a relationship between occlusion and temporomandibular joint function.

He hypothesised that changes in occlusion, such as a deep bite and loss of vertical dimension, led to changes in the temporomandibular joint's anatomy, resulting in ear symptoms (Costen, 1997). Similarly, Slavicek claimed that the contact relationships between teeth impacted the mandibular bone's three-dimensional position and that the eruption and coupling of permanent teeth impacted the TMJ's structural adaption (Slavicek, 2011).

However, there is a constant debate over the causal-effect relationship between malocclusion and TMD. More evidence proves that there is no role for malocclusion in causing TMD, nor is there evidence for orthodontic treatment as the cure for TMD (Dibbets et al., 1985, McNamara, 1997, Shroff, 2018).

Pathologies like obstructive sleep apnea syndrome (OSAS) that necessitate a multidisciplinary approach are frequently diagnosed by an orthodontist initially (*National guidelines for prevention and treatment of snoring and apnea syndrome obstructive sleep patterns in developmental age*, 2016). When someone has OSA, they

regularly stop breathing briefly while they sleep. It happens when the upper airway becomes blocked while sleeping because the tongue and the airway dilator muscles have inadequate motor tone (Park et al., 2011).

Currently, OSA is recognised as an independent risk factor for the development of several comorbid disorders as well as mortality. Malocclusion is a type of maxillofacial anomaly identified as a key contributing factor to mouth breathing. This form of breathing during sleep is frequently associated with the tongue shifting backwards and obstruction of the upper airway in the retropalatal and retroglottal areas (Hida et al., 1995, Lyberg et al., 1989).

High nasal resistance, lateral narrowing of the upper oral cavity, and altered tongue position are all caused by nasal obstruction in combination with maxillary constriction, which narrows the retroglottal airway in OSA patients (Seto et al., 2001). This problem is further worsened by the patient's inability to achieve normal lip closure in the case of increased overjet (Miyao et al., 2008). Another study revealed that a convex facial profile and class II malocclusion were more common in the OSA group (Banabilh et al., 2010).

Studies suggest that malocclusion may be associated with bullying in school, even with low certainty of evidence (Miranda e Paulo et al., 2022, Tristão et al., 2020). A child may be the target of harassment, which leads to a low quality of life, emotional instability, low self-esteem and lack of confidence due to the altered dentofacial appearance. It may result in poor social and academic performance (Morales-Salazar et al., 2022). The traits of malocclusion that have the most robust relation to bullying were extreme maxillary overjet, extreme deep overbite, having space between anterior teeth or missing teeth (Tristão et al., 2020).

2.5 Early interceptive orthodontics

The AAO's Council of Orthodontic Education defines interceptive orthodontics as "that phase of the science and art of orthodontics employed to recognise and eliminate potential irregularities and malpositions in the developing dentofacial complex". Ackerman and Proffit define interceptive orthodontics as the "elimination of existing interferences with the key factors involved in the development of the dentition" (Ackerman and Proffit, 1980).

The primary aim of interceptive orthodontics is to correct or intercept a malocclusion to reduce the complexity or even the necessity for treatment. It has been said that in 15% of cases, simple interceptive orthodontic treatment might completely correct the developing issues in mixed dentition, and in 49% of cases, it could improve them (Ackerman and Proffit, 1980). Before the full eruption of the permanent teeth, the early orthodontic intervention aims to enhance skeletal, dentoalveolar and muscular development (Oancea et al., 2019). Interceptive orthodontics may improve the malocclusion condition and reduce the need for more treatment (al Nimri and Richardson, 2000) but does not produce finished-quality results (King and Brudvik, 2010).

A study was conducted in Finland among children from 8 to 12 years of age, and the result showed that early orthodontic treatment may reduce the treatment need (Väkiparta et al., 2005). A similar study was done in Singapore to study the treatment outcome of interceptive orthodontics treatment among children with a mean age of 10. The overall success rate of interceptive orthodontics treatment was 75.5% (Song et al., 2020).

By far, no study has been done on the success rate of interceptive orthodontic treatment in Malaysia. A study assessed the feasibility of IOTN among Malaysian children 8-10 years old (Mohamed et al., 2014). The result revealed that more than half (62.2%) of the children were graded IOTN grades 3, 4 and 5, indicating the need for orthodontic treatment. This study concluded that index IOTN was unsuitable for mixed-dentition children as it is more challenging to determine tooth displacement in mixed dentition accurately. Moreover, the IOTN does not include the diagnosis for the centreline shift. Nonetheless, from this study, it was worth noting that most mixed dentition children need interceptive orthodontic treatment. A review article commented on the importance of early detection and appropriate referral of interceptive orthodontic cases (Wong et al., 2004). Inappropriate referrals will cause long waiting times for consultation for new patients (Reddy et al., 2016, O'Brien et al., 1996, Russell et al., 1999).

2.5.1 Timing of orthodontic treatment

The scientific literature debates the optimal timing to start children's orthodontic treatment (Martu et al., 2018). Some suggested that the ideal time to begin orthodontic treatment, which is aimed at growth modification, is commonly the late mixed dentition, just before the loss of the second deciduous molars (Cobourne and DiBiase, 2015). The phase of the late mixed dentition or early permanent dentition often coincides with a period of maximal growth, making it possible to correct growth-related malocclusion effectively. It may also allow for using the leeway space and provides permanent teeth to retain appliances and definitive correction of malocclusion (Fleming, 2017).

However, in early orthodontic treatment, as soon as the upper lateral incisors erupt in the early mixed dentition, it is ideal to start Phase 1 treatment. In cases with a crossbite, Class II and III malocclusion with crowding, early treatment is typically not considered in the primary dentition (Prasad et al., 2011). Phase 1 often entails active therapy for 6 to 12 months, intending to alter skeletal and dental relationships. When the appropriate permanent teeth have erupted, phase 2 is the “finishing” procedure. Theoretically, there are several potential reasons to initiate early orthodontic treatment before the late mixed dentition period, some of which include the improvement of access for oral hygiene maintenance in the case of crowding, psychosocial benefit (e.g. persistent teasing and bullying), growth response and aetiology of malocclusion (Fleming, 2017).

Yet, in other cases, early intervention does not significantly alter the environment for dentofacial development and the eruption of permanent teeth. Early intervention in such cases may increase treatment time and cost, and it may also lead to patient burnout in later years (Malhotra, 2018). The main concern of this controversy regarding the timing of orthodontics is whether treatment initiated during the early mixed dentition period of development is more beneficial than treatment started during the late mixed dentition stage or the permanent dentition (Gianelly, 1995).

Compellingly, a study reported that most orthodontists initiate orthodontic treatment in the permanent dentition stage. At the same time, paediatric dentists commonly started orthodontic management in the primary and the early-mixed dentition stages, followed by late-mixed and permanent dentition stages, which was the opposite treatment timing to the orthodontists (Aldrees et al., 2015).

A large-scale cross-sectional study in Italy among children between 2 and 13 years old was conducted to identify the prevalence of malocclusion and associated risk factors. The study suggested early orthodontic intervention in malocclusion that some risk factors may worsen during growth. Environmental risk factors have less of an impact on some malocclusion. Delaying the treatment until adolescence in these situations would be preferable. (Grippaudo et al., 2020). Nonetheless, for children with prominent upper front teeth, early orthodontic treatment (7 to 11 years old) is more effective in lowering the occurrence of incisal trauma than providing orthodontic treatment in adolescence (12 to 16 years old) (Batista et al., 2018).

A group of specialists and non-specialist providers committed to the routine delivery of "early" orthodontic treatment have provoked intense debate about the timing of orthodontic intervention (Wahl, 2006). A blanket prescription of early orthodontic treatment in malocclusion of skeletal and dental aetiology has yet to be proven to have additional benefits than later treatment (Sunnak et al., 2015). Currently, there is limited evidence to endorse routine interceptive orthodontic treatment before the age of 10 years old (Fleming and Andrews, 2023). The decision to early treatment should be made on a targeted basis to lessen the malocclusion severity or to make the need for extensive orthodontic treatment simpler or even avoidable.

2.6 The prevalence of orthodontic screening by dental therapists

The AAO recommends that the child visit an orthodontist for a check-up when malocclusion is recognised; however, by age seven. The screening process takes approximately three to four minutes in a community setting with rudimentary dental equipment from over fifty years ago (Rölling, 1978). A study in eastern Finland