

Etiology of Malocclusion and Dominant Orthodontic Problems in Mixed Dentition: A Cross-sectional Study in a Group of Thai Children Aged 8–9 Years

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INTRODUCTION

Malocclusion is rather a developmental disturbance than a disease.^[1] To date, many etiologies of malocclusion are still not clearly explained.^[2] Etiologies that cause malocclusion can affect different organs such as teeth, bone tissue, and/or neuromuscular components. Unfortunately, more than one etiologic factor is usually found in one patient.^[3]

Several authors classified etiologies of malocclusion in different patterns.^[4-8] Moyers^[4] classified the etiologies of malocclusion into six categories: hereditary, developmental cause of unknown origin, trauma, physical agents, habit, and diseases; whereas Proffit

ABSTRACT **Background:** Etiology of malocclusion can be the cause of deviation in the skeleton, dental, and soft tissue development in children. Identifying etiology of malocclusion and dominant orthodontic problems as well as early detection could help in future effective treatment, management, and public health planning. **Materials and Methods:** A cross-sectional study was performed among 202 children. Consensus process was carried out between experienced orthodontic experts in etiology of malocclusion, dominant orthodontic problems, type of early treatment, and malocclusion severity. Fisher's exact test and descriptive statistics were used to explain the study results. **Results:** Etiology of malocclusion was detected in both congenital and acquired etiology (64.3%), followed by acquired etiology only (29.7%). The top three dominant orthodontic problems were caries (22.5%), early loss of primary tooth (15.6%), and tendency of crowding in permanent dentition (14.6%). Nearly all the children needed restoration (86.4%) and interceptive orthodontic treatment (69.3%), whereas severe malocclusion level was found in one-fourth of the children (26.0%). Statistical significance was found between type of early treatment and malocclusion severity ($P < 0.001$). **Conclusion:** Acquired etiology was very high. Caries and early loss of primary teeth were dominant orthodontic problems. An early treatment, especially preventive orthodontic treatment, was needed in almost all children. Malocclusion severity higher than moderate level was found in more than half of the children.

KEYWORDS: Early treatment, etiology, malocclusion, mixed dentition, orthodontic treatment need

et al.^[8] classified the etiologies of malocclusion into three categories, which are specific causes of malocclusion, environmental influences, and genetic influences. Although some etiologies of malocclusion cannot be totally eliminated, they could be prevented and reduced by performing early treatment in the proper time to reduce the progression of some malocclusions.^[9]

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The early treatments, known as preventive and interceptive orthodontic treatment, can be performed during the development of dentition period when the child still has active growth.^[10] The purpose of early treatments is to enhance the proper dental and skeletal development by correction or early interception malocclusion. Early treatment can also reduce the severity of malocclusion and the treatment time in the permanent dentition.^[4,10,11] Early treatments were recommended for many malocclusion problems such as Class II malocclusion, Class III malocclusion, open bite, deep bite with palatal impingement, transverse problems, asymmetries with and without a functional shift, abnormal habits, ectopic eruption of molars and canines, crowding, large overjet, large diastema, and any congenital anomalies.^[10,12]

According to previous reports, most of the dentists could perform early treatments.^[13,14] A previous study in 2010 showed that non-orthodontic dentists in Thailand provided less interceptive orthodontic treatment than preventive orthodontic treatment.^[15] The additional training in holistic view was also suggested to improve the quality of the early treatment because malocclusion in each child had a unique characteristic that might not be corrected by the same early treatment technique.^[14] Moreover, the prevalence of caries and early loss in Thailand was very high.^[16] This occurrence might increase the number of children who needed early orthodontic treatment, which has never been investigated in Thailand, than that in the developed countries. The more complexity in malocclusion pattern found, the more consideration in the underlining etiologies seen that can cause malocclusion. Therefore, knowing etiologies of malocclusion is one of the essential portions in the early treatments. Prevalence in etiologies of malocclusion and type of early treatments are essential inputs in public health planning, especially in Thailand, which has limited resources.

Thus, this study was performed with an aim (1) to find the possible etiologies of malocclusion that indicate early treatments and (2) to identify the types of early orthodontic treatment in the group of children in the south of Thailand.

MATERIALS AND METHODS

ETHICAL APPROVAL

The study proposal submitted to the the Research Ethics Committee, Faculty of Dentistry, Prince of Songkla University and ethical approval was obtained (EC5810-30-P-LR). All children were invited to

participate in the after obtaining informed consent from their guardian.

STUDY DESIGN AND SUBJECTS

This study was a cross-sectional survey, which was performed during June to November 2016. Data collection was carried out in the schools in natural daylight. The population in the study consisted of all school children aged 8–9 years under the registration of District Primary Education Office in Hat Yai District, Songkhla Province, Thailand. Sample size was calculated to obtain a precision of ± 5 percentage point around an anticipated prevalence of preventive and interceptive orthodontic treatment need of 87%.^[17] Stratified and proportional sampling was used to choose both central and suburban schools. Afterward, simple random sample was performed to select the children. The consent forms were sent to children's guardians. The inclusion criteria were all children at age 8–9 years in the day of data collection. The exclusion criteria were noncooperative subject, cleft lip or cleft palate and other craniofacial syndrome, and having orthodontic devices. Noncooperative children and incomplete data collection reduced the sample to a total of 202, 100 boys (49.5%) and 102 girls (50.5%) with an average age of 8.46 years.

DATA COLLECTION FROM THE CHILDREN

Data were collected as follows: (1) extraoral photographs of the children at rest and smiling position, which were taken in frontal and lateral views, (2) intraoral photographs that consist of upper and lower dental arches, frontal, and lateral occlusal views, (3) orthodontic dental model, which was recorded in maximum intercuspation position, and (4) functional examination. Functional examination consisted of tongue thrusting habit, abnormal habit, abnormal labial frenum, lateral functional shift of the mandible, abnormal mouth breathing, and permanent tooth mobility. The tongue thrusting habit was recorded when the child presents both of the following characteristics: (1) having an interposition of the tongue between the anterior teeth, especially in the initial stage of swallowing and/or (2) having perioral muscle contraction (orbicularis oris and mentalis muscle) during swallowing.^[4] Abnormal habit included nonnutritive sucking and lip biting. Only mouth breather children were recorded in abnormal mouth breathing by using mouth mirror to examine the air flow from both nose and mouth.^[18] Abnormality of labial frenum was recorded by blanch test.^[8] Lateral functional shift of the mandible was recorded only when the child had any tooth interference (premature contact)

during lower jaw closing to maximum intercuspation position of more than 2mm. Permanent tooth mobility was examined only in the permanent tooth that had interference from the crossbite. Recorded would be done if that tooth had degree of mobility more than 1 mm in horizontal direction.

All photographs were taken by DSLR camera (Canon EOS D60) with macro lens (Canon EF-S 60mm f2.8 Macro USM) and ring flash (MR-14EX II) with check retractors and stainless steel mirror. Orthodontic dental model was obtained by alginate and immediately poured with dental stone. Maximum intercuspation position was recorded by wax bite. All functional examinations were performed under the portable dental chair and mouth mirror.

CONSENSUS PROCESS

Two diplomates of Thai Board Orthodontics experts, with more than 20 years of experience in orthodontic treatment, who still provide orthodontic treatment in mixed dentition, independently examined the collected information (photographs, orthodontic dental model, and functional examinations), each filling up a separate questionnaire. In case the answers of two experts differ, the consensus process will be carried out to find an outcome. In the case any non-consensus occurs, that child’s data would be excluded. Only agreements after the discussion were used for the data analysis [Figure 1].

DATA COLLECTION FROM EXPERTS

Etiologies of malocclusion

The possible etiologies of malocclusion used in this study were modified from Moyers’ classification (1988) as “congenital factors” and “acquired factors” [Table 1].^[4] The experts defined the possible etiologies as congenital, acquired, or both congenital and acquired.

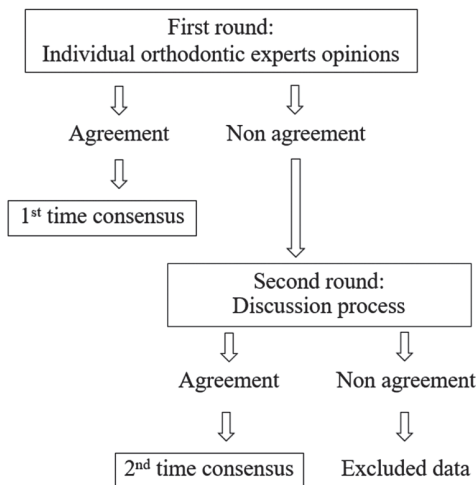


Figure 1: The consensus process between the orthodontic experts; only agreements in 1st time (individual opinions) and 2nd time (discussion opinions) were used for data analysis

Dominant orthodontic problems

Top three dominant orthodontic problems, which needed early treatment, were based on the previous studies.^[12,19,20] The grouping of dominant orthodontic problems was carried out as “congenital etiology,” “acquired etiology,” and “malocclusion.” The congenital etiology group consisted of tooth abnormality, absence of permanent tooth, active frenum, lip incompetent, and other skeleton and soft tissue abnormality. The acquired etiology group consisted of caries, early loss of primary tooth, prolonged retention of primary tooth, thumb sucking, and complete mouth breathing and tongue thrusting habit. The malocclusion group consisted of increased overjet, deep bite, open bite, anterior crossbite, posterior crossbite/scissors bite, tendency of crowding/spacing in permanent dentition, abnormality in first permanent molar relationship, first permanent molar tipping, first permanent molar rotation, and ectopic eruption of permanent tooth. In this topic, the experts could choose more than one to three orthodontic problems, which were (1) top three dominant characteristics, the three dominant characteristics indicated for early treatment need, and

Table 1: Classification of possible etiology used in this study (modified from Moyers^[4])

This study	Moyers’ etiology
Congenital	Genetic: craniofacial development and tooth and occlusal development Gross defect of a rare type: absence of muscles, micrognathia, facial cleft, oligodontia, and anodontia, which are unknown in origin
Acquired	Postnatal injury: fracture of jaw and teeth, TMJ trauma Premature extraction of primary teeth, nature of food Habits affect lip action and mastication: thumb sucking, tongue thrusting, lip sucking, lip biting, posture, nail biting, and others Local disease Nasopharyngeal disease and disturbed respiratory Gingiva and periodontal disease Tumors Caries Premature loss of primary teeth Disturbed in sequence of eruption of permanent teeth Loss of permanent teeth Quality of tissue (forming, calcification)
Unidentified	Prenatal injury: mandible hypoplasia, Vogelgesicht, facial asymmetry Systemic diseases and endocrine disorder Others

TMJ = temporomandibular joint

(2) the first rank, the most important characteristics indicated for early treatment need.

Type of early treatment

Type of early treatment was divided into three groups: (1) no treatment needed, (2) preventive orthodontic treatment, (3) interceptive orthodontic treatment, and (4) wait and see. The no treatment needed group referred to as no orthodontic treatment needed at this time (normal dental development/self-corrected problems). Type of preventive orthodontic treatment consisted of restoration, extraction of prolonged retention of primary tooth or unrestorable, space maintainer or prosthesis, habit correction without appliance, habit correction with appliance, and primary correction without appliance. Regarding interceptive orthodontic treatment, it would only be recorded that the treatment was needed or not. Wait and see group was remarked when it could not be determined at that time whether the children should receive treatment or not.

Malocclusion severity

The severity of malocclusion was determined in four levels: (1) no malocclusion/normal occlusion, (2) mild, (3) moderate, and (4) severe.

STATISTICAL ANALYSIS

The Statistical Package for the Social Sciences (SPSS) Statistics Base, version 17.0, for Windows EDU (SPSS, Chicago, Illinois) was used to find the association in (1) the etiology of malocclusion and type of early treatment between male and female and (2) malocclusion severity and type of early treatment by Fisher's exact test at 95% confidence interval. Descriptive statistics such as frequency and percentage were determined to present study results.

RESULTS

After receiving inputs from the experts, three children were excluded due to disagreement in the consensus process. A total of 199 children were then used in the study of etiologies of malocclusion, dominant orthodontic problems, and type of early treatment. Another three children in "wait and see category" were later excluded as there was no definite decision from experts. As a result, 196 children were finally used in the

analysis to detect the relationship between malocclusion severity and type of early treatment.

Table 2 shows the distribution of possible etiologies of malocclusion. Most children (64.3%) had both congenital and acquired etiologies, followed by acquired etiologies only (29.7%) and congenital only (4.5%). No statistical significance was found between boys and girls.

Top dominant orthodontic problems that required early treatment were shown in Table 3. The top three dominant orthodontic problems, which had the highest percentage were caries (22.5%), early loss of primary teeth (15.6%), and crowding in future permanent dentition (14.6%); whereas, anterior crossbite (21.8%), deep bite (14.7%), and caries (14.2%) were the top most three percentages for the first rank aspect. Interestingly, the dominant orthodontic problems in congenital etiology group were rare.

Table 4 shows the type of early treatment that this group of children needs. No statistical significance was found between boy and girl in each type of early treatment. The dominant preventive orthodontic treatment types were restoration (84.6%), extraction (69.8%), and space maintainer (60.8%). Habit correction need, such as tongue thrusting habit and hyperactivity of mentalist muscle, was indicated at only 7.0%. Primary correction without appliance, for instance, serial extraction and selective griddling, could be corrected in some children (5.0%), whereas interceptive orthodontic treatment was required in almost all children (69.3%).

The association between malocclusion severity and the type of early treatment was significant [Table 5]. One-third of children (30.4%) who needed only preventive orthodontic treatment had no malocclusion severity. This percentage was contrasting with the children who needed interceptive and/or preventive orthodontic treatment, which had malocclusion severity in moderate and severe level, 44.9% and 34.1%, respectively.

DISCUSSION

Proper oral health planning is also needed to reduce the malocclusion problems that can lead to more complicated orthodontic treatments in the permanent dentition.^[21] Even though an approximate one-third

Table 2: Distribution of possible etiology groups of malocclusion according to expert's opinion

Etiology group	Total, n (%)	Sex, n (%)		P value*
		Male	Female	
None	3 (1.5)	2 (66.7)	1 (33.3)	0.510
Congenital etiology only	9 (4.5)	3 (33.3)	6 (66.7)	
Acquired etiology only	59 (29.7)	33 (55.9)	26 (44.1)	
Both congenital and acquired etiology	128 (64.3)	62 (48.4)	66 (51.6)	
Total	199 (100.0)	100 (50.3)	99 (49.7)	

*Fisher's exact test, $\alpha = 0.05$

Table 3: Distribution of the top three dominant and first rank orthodontic characteristics, which indicated for early treatment need according to expert's opinion

Characteristics	n (%)	
	Top three ^a (n = 512)	First rank ^b (n = 197)
Congenital etiology		
Other tooth abnormalities	7 (1.4)	6 (3.1)
Absent permanent tooth	5 (1.0)	3 (1.5)
Active frenum	4 (0.8)	0 (0.0)
Other skeleton and soft tissue abnormality	4 (0.8)	1 (0.5)
Lip incompetent	0 (0.0)	0 (0.0)
Acquired etiology		
Caries	115 (22.5)	28 (14.2)
Early loss of primary tooth	80 (15.6)	22 (11.2)
Prolonged retention of primary tooth	9 (1.8)	3 (1.5)
Tongue thrust	7 (1.4)	1 (0.5)
Thumb sucking	0 (0.0)	0 (0.0)
Malocclusion		
Tendency of crowding in permanent dentition	75 (14.6)	26 (13.2)
Anterior crossbite	47 (9.2)	43 (21.8)
Deep bite	46 (9.0)	29 (14.7)
First permanent molar relationship	30 (5.9)	7 (3.6)
Overjet	22 (4.3)	5 (2.5)
First permanent molar tipping	15 (2.9)	4 (2.0)
Posterior crossbite/scissors bite	13 (2.5)	6 (3.1)
Ectopic eruption of permanent tooth	11 (2.1)	8 (4.1)
First permanent molar rotation	11 (2.1)	1 (0.5)
Tendency of spacing in permanent dentition	8 (1.5)	3 (1.5)
Open bite	3 (0.6)	1 (0.5)

^aTop three dominant characteristics, which led to the experts' decision (no more than three characteristics per child)

^bThe most dominant characteristics, which led to the experts' decision (only one characteristic per child)

of the children who had congenital etiology might not be completely corrected, early treatment may have reduced their malocclusion complexity.^[22] Therefore, both knowledge in etiology and management of malocclusion problems should be given more emphasis in the related undergraduate curriculum and trainings among the public health officials.

Most dominant orthodontic problems that needed early treatment are in acquired etiology and malocclusion groups. Therefore, the problems that were accepted to be the causes of malocclusion should be identified and be treated before the others. However, it does not mean that the congenital factors are negligible as some congenital factors may be attenuated by the early orthodontic intervention.^[23]

Many children had multiple problems that disturb the normal development of the occlusion. The top three dominant orthodontic problems indicated by the experts are caries, early loss of primary tooth, and tendency of crowding in permanent dentition. Caries that is one of the etiologies in early loss of primary tooth and crowding in permanent dentition is advised to be treated as soon as possible. Comparing with a comparable study in India, this study showed higher percentage of both caries (86.4% vs. 75.5%) and orthodontic treatment need (69.3% vs. 15.0%).^[24] The reason might be due to the different sources of data collection and different protocols in the measurement of orthodontic treatment need. From the recent evidence, the interproximal caries had some relationship with the malocclusion traits such as crowding, overjet, anterior crossbite, and angle classification.^[25] The prevention and correction in the tendency of crowding in permanent dentition is recommended in this age group because it could help increase arch parameter.^[26] Beside the caries problem, it is not surprising that anterior crossbite and deep bite were the characteristics that the experts indicated to be the first rank, which lead to early treatment need. The benefits in correction of anterior crossbite and deep bite in this age group were the providing of normal development of dentoalveolar structure and jaw movement.^[12]

According to the very high percentage in preventive orthodontic treatment such as restoration, extraction of prolonged retention of primary tooth or unrestorable, and space maintainer, it could be implied that the children in this study had more than one problem and might need more than one method of early treatment. This occurrence would be a heavy workload for concerned health personnel. Although many practitioners were willing to perform the early treatment, some children might need specific handling due to its complexity.^[14,15] The proper case selection, continuing education, and supplemental training are recommended.

Primary oral health care is extremely required in this group of children, especially in caries prevention.^[21,27] The caries prevention dose not only reduce disability in chewing efficiency but also reduce the malocclusion problems. Thus, the lesser of the caries in mixed dentition, the lesser resources and manpower were required to correct the malocclusion problems in the permanent dentition.

The relationship between the type of preventive and interceptive orthodontic treatment reveals that the more severe malocclusion, the higher level of early treatment will be required. However, some children with moderate-to-severe malocclusion need only

Table 4: Distribution of type of early treatment according to expert's opinion (n = 199)

Type of early treatment	Total, n (%)	Sex, n (%)		P value*
		Male	Female	
Preventive orthodontic treatment				
Restoration				
No	27 (13.6)	12 (44.4)	15 (55.6)	0.542
Yes	172 (86.4)	88 (51.2)	54 (48.8)	
Extraction of prolonged retention of primary tooth or unrestorable				
No	60 (30.2)	31 (51.7)	29 (48.3)	0.877
Yes	139 (69.8)	69 (49.6)	70 (50.4)	
Space maintainer or prosthesis				
No	78 (39.2)	36 (46.2)	42 (53.8)	0.386
Yes	121 (60.8)	64 (52.9)	57 (47.1)	
Habit correction without appliance				
No	195 (98.0)	98 (50.3)	97 (49.7)	1.000
Yes	4 (2.0)	2 (50.0)	2 (50.0)	
Habit correction with appliance				
No	189 (95.0)	95 (50.3)	94 (49.7)	1.000
Yes	10 (5.0)	5 (50.0)	5 (50.0)	
Primary correction without appliance				
No	189 (95.0)	96 (50.8)	93 (49.2)	0.537
Yes	10 (5.0)	4 (40.0)	6 (60.0)	
Interceptive orthodontic treatment				
No	61 (30.7)	32 (52.3)	29 (47.5)	0.759
Yes	138 (69.3)	68 (49.3)	70 (50.7)	
Wait and see				
No	196 (98.5)	99 (50.5)	97 (49.5)	0.621
Yes	3 (1.5)	1 (33.3)	2 (66.7)	

*Fisher's exact test, $\alpha = 0.05$ **Table 5: Relationships between malocclusion severity and type of early treatment (n = 196^a)**

Type of early treatment	Total, n (%)	Malocclusion severity, n (%)				P value ^b
		No	Mild	Moderate	Severe	
No	2 (0.0)	2 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)	<0.001*
Preventive	56 (28.6)	17 (30.4)	21 (37.5)	14 (25.0)	4 (7.1)	
Interceptive with/without preventive	138 (70.4)	0 (0.0)	29 (21.0)	62 (44.9)	47 (34.1)	

*Significant at $\alpha = 0.05$ ^aExcluded sample in wait and see category^bFisher's exact test

preventive orthodontic treatment. This manifestation shows that the malocclusion might be too complicated to be corrected by interceptive orthodontic treatment at this time and will inevitably need later comprehensive orthodontic treatment.

Fortunately, approximately one-third of the children who needed only preventive orthodontic treatment had no malocclusion. These children would greatly benefit from the early treatment as they presented no malocclusion. The data from this study may raise the awareness of the health personnel in the early detection of deviated malocclusion to give a golden opportunity in this group of children.

One of the limitations of this study was that the sample, which mostly comes from the rural area might have some

barriers to assess the public oral health service, such as transportation and income problems.^[28] However, this study reflected the high demand in preventive and interceptive orthodontic treatment need around this location, which needed the intensive oral health care. Even though, the cause of malocclusion could be identified in genetic basis, many different variables had an influence during malocclusion development.^[29] This study aimed to clarify the etiologies of malocclusion and to indicate early treatment needed in the children with mixed dentition in a high caries prevalence situation, limitations of result may arise in countries where a better oral health care exists. It is expected that this study, in which a different classification in etiologies of malocclusion was used, could provide beneficial data

for the future study and management of the preventive oral health as it sought to identify preventable etiologies from those which could not be prevented. Moreover, the indication of early treatment in orthodontic perspective would help raise the awareness of public health personnel in both prevention and treatment handling aspect.

CONCLUSION

In these groups of children,

- Acquired etiology, especially caries, is an outstanding cause of malocclusion.
- Dominant orthodontic problems were caries, early loss of primary teeth, and tendency of crowding in permanent teeth.
- Interceptive orthodontic treatment, restoration, and extraction of primary teeth are common early treatments needed.
- More than half of the children had malocclusion with severity equal or more than moderate level.
- Appropriate planning in caries prevention is recommended to reduce malocclusion problems.

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CONFLICTS OF INTEREST

There are no conflicts of interest.

REFERENCES

1. Leighton BC. Aetiology of malocclusion of the teeth. *Arch Dis Child* 1991;66:1011-2.
2. Proffit WR. On the aetiology of malocclusion. The Northcroft lecture, 1985 presented to the British Society for the Study of Orthodontics, Oxford, April 18, 1985. *Br J Orthod* 1986;13:1-11.
3. Hassan R, Rahimah A. Occlusion, malocclusion and method of measurements—An overview. *Arch Orofac Sci* 2007;2:3-9.
4. Moyers RE. *Handbook of Orthodontics*. London, UK: Year Book Medical Publisher; 1988. p. 147-63.
5. Graber TM. *Orthodontics Principles and Practice*. 3rd ed. Philadelphia, PA: WB Saunders; 1972. p. 255-396.
6. Shaw WC. Orthodontics and occlusal management. *Br Dent J* 1994;177:120-1.
7. Salzmann JA. *Practice of Orthodontics*. 1st ed. Philadelphia, PA: Lippincott; 1966. p. 103-24.
8. Proffit WR, Fields Jr. HW, Larson BE, Sarver DM. *Contemporary Orthodontics*. 6th ed. Philadelphia: Elsevier; 2019. p. 107-36.
9. Zou J, Meng M, Law CS, Rao Y, Zhou X. Common dental diseases in children and malocclusion. *Int J Oral Sci* 2018;10:7.
10. Bishara SE, Justus R, Graber TM. Proceedings of the workshop discussions on early treatment. *Am J Orthod Dentofacial Orthop* 1998;113:132-6.
11. Kerosuo H. The role of prevention and simple interceptive measures in reducing the need for orthodontic treatment. *Med Princ Pract* 2002;11:16-21.
12. American Academy on Pediatric Dentistry Clinical Affairs Committee-Developing Dentition Subcommittee. American Academy on Pediatric Dentistry Council on Clinical Affairs. Management of the developing dentition and occlusion in pediatric dentistry. *Pediatr Dent* 2017;39:334-47.
13. Kapoor D, Bhatia S, Garg D. Assessment of the attitude and knowledge of the principles and practices of orthodontic treatment among the non-orthodontic specialists and general practitioner dentists. *JNMA J Nepal Med Assoc* 2018;56:766-9.
14. Pintongpant R, Suntornlohanakul S, Thearmontree A. Appropriated referral and basic treatments of orthodontic patients for non-orthodontic dentists: The perspectives of orthodontists. *J Dent Assoc Thai* 2011;61:165-75.
15. Sanguandeeikul A, Thearmontree A, Suntornlohanakul S. Factors associated with referral of orthodontic patients and basic orthodontic treatments by non-orthodontic dentists. *J Dent Assoc Thai* 2012;60:95-107.
16. Rapeepattana S, Suntornlohanakul S, Thearmontree A. Orthodontic treatment needs of children with high caries using Index for Preventive and Interceptive Orthodontic Needs (IPION). *Eur Arch Paediatr Dent* 2019. <https://doi.org/10.1007/s40368-019-00453-5>
17. Haider Z. An epidemiologic survey of early orthodontic treatment need in Philadelphia pediatric dental patients using the Index for Preventive and Interceptive Orthodontic Needs (IPION) [dissertation]. Philadelphia, PA: Temple University; 2013.
18. Rakosi T, Jonas I, Graber TM. *Orthodontic Diagnosis*. New York: Thieme Medical Publishers; 1993. p. 57-90.
19. Shalish M, Gal A, Brin I, Zini A, Ben-Bassat Y. Prevalence of dental features that indicate a need for early orthodontic treatment. *Eur J Orthod* 2013;35:454-9.
20. Karaiskos N, Wiltshire WA, Odlum O, Brothwell D, Hassard TH. Preventive and interceptive orthodontic treatment needs of an inner-city group of 6- and 9-year-old Canadian children. *J Can Dent Assoc* 2005;71:649.
21. Kwan SY, Petersen PE, Pine CM, Borutta A. Health-promoting schools: An opportunity for oral health promotion. *Bull World Health Organ* 2005;83:677-85.
22. Alkilzy M, Shaaban A, Altinawi M, Splieth ChH. Epidemiology and aetiology of malocclusion among Syrian paediatric patients. *Eur J Paediatr Dent* 2007;8:131-5.
23. Fleming PS. Timing orthodontic treatment: Early or late? *Aust Dent J* 2017;62:11-9.
24. Prasad MG, Radhakrishna AN, Kambalimath HV, Chandrasekhar S, Deepthi B, Ramakrishna J. Oral health status and treatment needs among 10,126 school children in West Godavari District, Andhra Pradesh, India. *J Int Soc Prev Community Dent* 2016;6:213-8.
25. Caplin JL, Evans CA, Begole EA. The relationship between caries and malocclusion in Chinese migrant workers' children in Shanghai. *Chin J Dent Res* 2015;18:103-10.
26. Barrow GV, White JR. Developmental changes of the maxillary and mandibular dental arches. *Angle Orthod* 1952;22:41-6.
27. Skeie MS, Klock KS. Dental caries prevention strategies among children and adolescents with immigrant - or low socioeconomic backgrounds- do they work? A systematic review. *BMC Oral Health* 2018;18:20.
28. Almutlaqah MA, Baseer MA, Ingle NA, Assery MK, Al Khadhari MA. Factors affecting access to oral health care among adults in Abha City, Saudi Arabia. *J Int Soc Prev Community Dent* 2018;8:431-8.
29. Ahmed MK, Ye X, Taub PJ. Review of the genetic basis of jaw malformations. *J Pediatr Genet* 2016;5:209-19.