



Estimation of the prevalence of malocclusion on the basis of nationwide oral health examinations of pre-adolescent and adolescent students during 2012–2017

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Objective: To investigate the prevalence of malocclusion with respect to grade, sex, and year among Korean pre-adolescent and adolescent students during 2012–2017. **Methods:** A total of 165,996 students (first grade [E1, 6–7 years of age], fourth grade [E4, 9–10 years], seventh grade [M1, 12–13 years], and tenth grade [H1, 15–16 years]) were selected by stratified sampling method and underwent the nationwide oral health examination performed by the Ministry of Education, Republic of Korea. The malocclusion assessments based on dentists' judgments were “no malocclusion,” “needs orthodontic treatment (N-OTx),” and “under orthodontic treatment (U-OTx).” The sum of N-OTx and U-OTx cases was determined as the number of students with malocclusion. After analyzing the prevalence of malocclusion according to grade, sex, and year-by-year differences, Pearson correlation analyses and two-way analyses of variance were performed. **Results:** The prevalence of malocclusion was 18.7%, which increased with the grades (E1 [8.3%] < E4 [15.8%] < M1 [22.9%] < H1 [25.3%], $p < 0.001$). However, there was no significant difference in the prevalence of malocclusion in each grade group for the period ($p > 0.05$) without significant correlation (E1, $\rho = 0.129$; E4, $\rho = -0.495$; M1, $\rho = 0.406$; H1, $\rho = -0.383$; all $p > 0.05$). The prevalence of malocclusion within each grade group over the six-year period was more prominent in the female ($p < 0.0001$). **Conclusions:** Further studies are necessary to modify the malocclusion assessment method to account for specific types of malocclusion in pre-adolescent and adolescent students. [Korean J Orthod 2020;50(3):197–205]

Key words: Prevalence of malocclusion, Nationwide oral health examination, Malocclusion assessment, Preadolescent and adolescent students

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INTRODUCTION

The low birth rate in Korea, Republic (KR) has recently become a serious social issue. According to KR statistics,¹ the population of children is projected to decrease from 7,030,000 persons (13.8%) in 2015 to 5,980,000 persons (11.3%) in 2035, and to 4,130,000 persons (9.6%) in 2065. Furthermore, the Korean Dental Association reported that 1,395 orthodontic specialists have been certified since 2008.² Therefore, there are increasing concerns regarding a potential reduction in the demand for orthodontic treatment in the future and increased competition among orthodontists under the new professionalism system.

Epidemiological studies are useful for measuring the distribution of specific diseases in the population and for planning and evaluating healthcare services, such as professional education and the doctor-to-patient ratio. The estimated prevalence of malocclusion in a particular population can provide basic information about the supply and demand of professional health care providers. Several studies have attempted to measure the orthodontic treatment needs and estimate the prevalence of malocclusion in specific communities, yielding descriptive data for the distribution of individuals seeking orthodontic treatment in specific populations.³⁻⁶

In KR, numerous epidemiologic studies have been conducted using community surveys,^{7,8} longitudinal dental hospital data analyses,⁹⁻¹⁷ and longitudinal local dental clinic data analyses.^{18,19} However, these studies share a common limitation in that they are not based on nationwide sampling or survey data. In this regard, the Ministry of Education, KR has conducted an annual oral health examination for pre-adolescent and adolescent students since 2008, and the data from this survey can be reorganized as a secondary dataset for estimating the prevalence of malocclusion. To our knowledge, there has been no published study including nationwide assessment of malocclusion in pre-adolescent and adolescent students. Therefore, the purpose of this study was to investigate the prevalence of malocclusion in relation to grade, sex, and year in pre-adolescent and adolescent students of KR during 2012–2017.

MATERIALS AND METHODS

Subjects

In this study, for the purpose of homogeneity of sampling methods, the analyzed data were based on oral health examinations for pre-adolescent and adolescent students conducted from 2012 to 2017. For stratified sampling, the primary unit was “school” and the secondary unit was “classroom”. Selection of “school” was based on probability proportional to size sampling.

For the secondary unit, complete enumeration for one classroom of the primary unit school was fulfilled. For example, in 2017, a total of 764 schools, including 250 elementary schools, 254 middle schools, and 260 high schools, were selected.

The final sample was extracted from one whole classroom of each school: the first grade (E1; student age, 6–7 years) and fourth grade (E4; age, 9–10 years) of elementary schools, the first grade of middle schools (7th grade, M1; age, 12–13 years), and the first grade of high schools (10th grade, H1; age, 15–16 years). The reason of selecting these grades was that the dental ages at E1, E4, M1, and H1 might represent the early mixed dentition stage, late mixed dentition, early permanent dentition, and permanent dentition, respectively. The final samples consisted of 165,996 students including 33,743 students for E1, 33,856 students for E4, 47,051 students for M1, and 51,346 students for H1 (Table 1).²⁰ This study was reviewed and approved by the Institutional Review Board of the Kyungpook National University Dental Hospital (KNUDH-2009-11-04-00).

Assessment of malocclusion

Each student in the final sample visited a dental clinic for an oral health examination that included evaluation of dental caries, missing teeth, soft tissue disease, malocclusion, and oral hygiene (Figure 1). Assessment of malocclusion was carried out by dentists' judgments and divided into “no malocclusion (N-M),” “needs orthodontic treatment (N-OTx),” and “under orthodontic treatment (U-OTx).” The criteria for assigning “N-OTx” and “N-M” were the presence of a class I occlusion and normal overbite/overjet, respectively. The number of students with malocclusion was calculated as the sum of N-OTx and U-OTx cases.

Statistical analysis

This secondary longitudinal dataset was reorganized to analyze the prevalence of malocclusion according to grade, sex, and year-by-year differences. Descriptive statistics, two-way analysis of variance (ANOVA), and Pearson correlation analysis were performed for statistical analysis. Two-way ANOVA was designed to assess the interrelationship of the variables grades and sex on the prevalence of malocclusion. IBM SPSS Statistics ver. 23.0 (IBM Corp., Armonk, NY, USA) was used. A *p*-value of < 0.05 was considered significant.

RESULTS

The estimated prevalence of major oral diseases

The mean prevalence of dental caries was 27.6% (range, 23.6–30.9%), followed by malocclusion (mean, 18.7%; range, 16.9–20.3%) and periodontitis (mean,

Table 1. The estimated prevalence of malocclusion in nationwide oral health examinations during 2012–2017

Year	Elementary school			Middle school			High school			Total		
	E1		E4	M1		H1	H1		Total	Total		
	Number	% of malocclusion		Number	% of malocclusion		Number	% of malocclusion		Number	% of malocclusion	
2012	5,848	7.0	5,912	16.0	8,734	21.7	8,572	24.3	29,066	18.3		
2013	5,679	8.5	5,776	16.4	8,461	23.0	8,258	26.6	28,174	19.7		
2014	5,639	9.4	5,584	17.2	7,787	23.3	8,129	28.7	27,139	20.3		
2015	5,553	8.2	5,481	14.4	7,437	23.1	8,883	23.8	27,354	17.8		
2016	5,545	9.4	5,486	16.5	7,419	23.7	9,086	25.3	27,536	19.3		
2017	5,479	7.2	5,617	14.3	7,213	22.4	8,418	23.1	26,727	16.9		
Sum	33,743	-	33,856	-	47,051	-	51,346	-	165,996	-		
Mean	5,623.8	8.3	5,642.7	15.8	7,841.8	22.9	8,557.7	25.3	27,666	18.7		
p-value*	0.129		-0.495		0.406		-0.383		-0.449			
p-value†	0.808		0.318		0.425		0.454		0.372			

Source of numbers and % values: annual reports of national students health examination results from 2012 to 2017.²⁰

E1, The first grade of elementary school; E4, the fourth grade of elementary school; M1, the first grade of middle school (seventh grade); H1, the first grade of high school (tenth grade).

*Pearson correlation coefficient value across years in each grade group, †Pearson correlation analysis was performed across years in each grade group.

14.6%; range, 13.2–17.0%) (Figure 2).²⁰

Year-by-year changes in the prevalence of malocclusion

There was no significant correlation for each grade group across all years (E1, $\rho = 0.129$; E4, $\rho = -0.495$; M1, $\rho = 0.406$; H1, $\rho = -0.383$; all $p > 0.05$; Table 1). Therefore, the prevalence of malocclusion in each grade group did not present annual differences.

Changes in the prevalence of malocclusion according to sex*grade

A two-way ANOVA was conducted to compare the prevalence of malocclusion in relation to sex and grades, considering type II error. Significant main effects were observed for both grade ($f = 327.151, p < 0.0001$) and sex ($f = 53.584, p < 0.0001$). However, grade*sex did not show a significant interactive effect ($f = 1.275, p = 0.296$) (Table 2).²⁰

Changes in the prevalence of malocclusion according to sex and grades

The mean prevalence of malocclusion increased with grade (E1 [8.3%] < E4 [15.8%] < M1 [22.9%] < H1 [25.3%], $p < 0.001$; Table 2). Thus, higher grades corresponded to a higher prevalence of malocclusion. Female participants showed a higher prevalence of malocclusion than did male participants ($p < 0.0001$; Table 2). However, there was no significant correlation for this relationship in each grade during the study period (all $p > 0.05$, Table 1). Therefore, it can be stated that the prevalence of malocclusion tended to be greater in the female participants in each grade group over the six-year study period.

DISCUSSION

The estimated prevalence of major oral diseases

In this study, 18.7% of subjects had malocclusion, which showed a prevalence lower than that of dental caries (27.6%) but higher than that of periodontitis (14.6%) (Figure 2). While the prevalence of dental caries reduced from 2012 to 2017, the prevalences of malocclusion and periodontitis remained steady during these years (Figure 2).

There is some controversy regarding the relationships between malocclusion and other oral diseases. Arora and Bhateja²¹ insisted that malocclusion did not have a significant effect on the prevalence of dental caries and periodontitis among 12-year-old school children. However, a positive correlation between the degree of malocclusion severity and the existence of dental caries was reported in the primary dentition by Disha et al.²² and among students aged 11–15 years by Baskaradoss et al.²³ This relationship should be investigated using more so-

Oral Health Examination Report											
Name of school			Grade/class/number								
Name			Resident registration number								
Dental examination result and judgement											
Common items for elementary, middle, and high schools						Additional item for middle and high schools					
Dental caries	① No	② Yes	Maxilla() Mandible()		Periodontal disease	① No	② Yes	gingival bleeding/enlargement() calculus() paradental cyst() other()			
Dental caries risk	① No	② Yes	Maxilla() Mandible()			① No	② Yes				
Missing (permanent teeth)	① No	② Yes	Maxilla() Mandible()		TMJ pain	① No	② Yes				
Canker sore and tissue defect	① No	② Yes ()			Additional item for high schools						
Malocclusion	① No	② Yes	③ Under treatment			Abrasion	① No	② Yes			
Oral hygiene status	① excellent	② normal	③ needs improving			Third molars	① Normal	② Abnormal ()			
Others	① Supernumerary teeth	② retained primary teeth	③ Other dental conditions								
Comprehensive Assessment											
Comprehensive Assessment						Actions at home					
Dentist examined	License No.	Examiner's name	(sign)	Examined date, Institution/office	Date, Name						

This survey is to understand your oral symptoms and oral health behaviors before oral health examinations. The results of the survey will be referenced at the time of examination, and the content will be confidential. Your honest and sincere answer will be of great help to yourself. It must be completed by yourself, but please consult with your parents (guardians) for details that you do not know.

the question of oral symptoms the question of oral health behavior

※ Please check (V) all the symptoms you've experienced in the last year.

Symptoms	① Yes	② No
1. I have broken teeth.		
2. I feel my teeth aching when I eat something cold or hot.		
3. I have toothache.		
4. I have frequent bleeding gums.		
5. I have a throbbing pain in the tongue or cheek of the mouth.		
6. I have bad breath.		

※ Please check (V) the number corresponding to your oral health

7. Have you ever gone to the dentist over the past year?
① Yes ② No ③ I don't know

8. Please check when you brush your teeth during the yesterday.
① Before breakfast
② After breakfast
③ After lunch
④ After supper
⑤ Right before sleep
⑥ After eating between meals

9. Do you like eating sweet food and soda?
① Yes ② average ③ No

10. Do you have fluoride in your toothpaste?
① Yes ② No
③ Don't know what fluoride toothpaste is

※ Write down what you want to say to the dentist in particular.

Figure 1. Oral health examination form for pre-adolescent and adolescent students provided by the Ministry of Education, Korea.

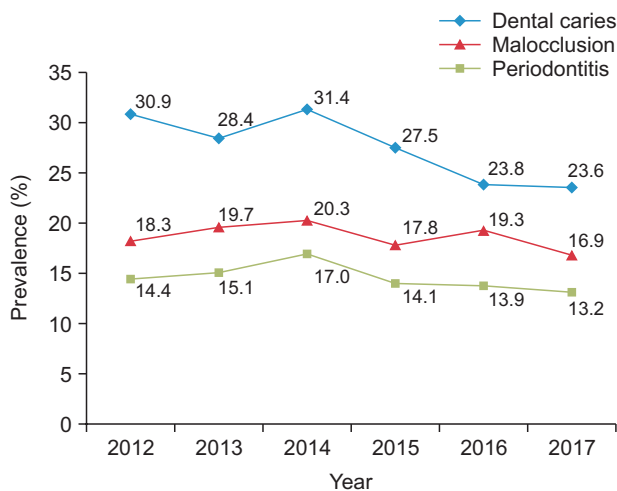


Figure 2. Trend of changes in the estimated prevalence of major oral diseases across nationwide oral health examinations during 2012–2017. The stratified and extracted samples consisted of students in the first grade (elementary school), fourth grade (elementary school), seventh grade (middle school), and tenth grade (high school). Source of origin: annual reports of national students health examination results from 2012 to 2017.²⁰

phisticated malocclusion assessment methods and larger sample sizes with nationwide oral health examination.

The estimated prevalence of malocclusion

The prevalence of malocclusion in this study was estimated to be 18.7%. However, the prevalence of malocclusion among growing children has been reported to range from 39–93%.^{22,24–26} This discrepancy can be attributed to differences in ethnicity, age, and the criteria and methodologies used for assessment. In terms of the criteria and methodologies used for assessment, previous studies used Angle’s classification, index of orthodontic treatment need (IOTN), dental esthetic index (DAI), and treatment priority index (TPI)^{24,27}; while the present study used three criteria categorized as N-M, N-OTx, and U-OTx (Figure 1).

Comparison of the estimated prevalence of malocclusion in the Korean population

In Table 3, we have summarized the results from previous Korean epidemiologic studies on the distribution of malocclusion type or utilization of orthodontic treatment services. Although the majority of previous

Table 2. Comparison of the estimated prevalence of malocclusion with respect to grade and sex

Group		Value*	
Elementary school	E1 (33,743)	Number	5,623.8
		Total (%)	8.3
		Male (%)	7.4
		Female (%)	9.2
	E4 (33,856)	Number	5,642.7
		Total (%)	15.8
		Male (%)	14.3
		Female (%)	17.4
Middle school	M1 (47,051)	Number	7,841.8
		Total (%)	22.9
		Male (%)	21.0
		Female (%)	24.9
High school	H1 (51,346)	Number	8,557.7
		Total (%)	25.3
		Male (%)	23.3
		Female (%)	27.0
Total (165,996)		Number	27,666
		Total (%)	18.7
		Male (%)	16.5
		Female (%)	19.6
<i>p</i> -value		Grade: E1 < E4 < M1 < H1, <i>p</i> < 0.0001; Sex: Male < Female, <i>p</i> < 0.0001; Grade*Sex, <i>p</i> = 0.296	

p-value from two-way analysis of variance test regarding two factors including four grade levels and sex.

E1, The first grade of elementary school; E4, the fourth grade of elementary school; M1, the first grade of middle school (seventh grade); H1, the first grade of high school (tenth grade).

*Secondary data based on raw data from annual reports of national students health examination results from 2012 to 2017.²⁰

studies used Angle's classification to determine malocclusion type,^{7,9-19} only one study used the malocclusion indices (handicapping labiolingual deviation; TPI; and handicapped malocclusion assessing record).⁸ However, these previous studies had inevitable limitations, including small sample sizes, specific hospital patients or local clinic patients, and inability to calculate the prevalence of malocclusion.

The prevalence of malocclusion reported by Suhr et al.⁷ was much higher than that noted in this study (61.2 vs. 18.7%). Although the study by Suhr et al.⁷ was the only study that reported the prevalence of malocclusion in Korean students among previous Korean epidemiological studies, they regarded the sum of cases showing Angle's class I (45.7%), class II (7.6%), and class III (7.9%) cases as those requiring orthodontic treatment. However, a high prevalence of malocclusion on the basis of Angle's classification did not necessarily indicate the needs for orthodontic treatment.²⁶ Furthermore, the approach of counting class I malocclusion cases as those requiring

orthodontic treatment might result in over-estimation of the prevalence of malocclusion.

Changes in the prevalence of malocclusion according to grades

In the present study, the prevalence of malocclusion increased with grades (8.3% for E1, 15.8% for E4, 22.9% for M1, and 25.3% for H1; E1 < E4 < M1 < H1, *p* < 0.001; Table 2). These findings indicate that the number of students with malocclusion in the permanent dentition was higher than those in the mixed dentition (M1 + H1, *n* = 98,397/165,996 [59.3%] vs. E1 + E4, *n* = 67,599/165,996 [40.7%]; Table 1).

For malocclusion in the mixed dentition stage, such as those encountered in E1 and E4, the skeletal malocclusion type might primarily influence the type of orthodontic treatment required. However, for malocclusion in the permanent dentition stage, such as those observed in M1 and H1, both skeletal and dental malocclusion types might influence the type of orthodontic

Table 3. Summary of previous epidemiologic studies on malocclusion assessment in Korea

Author (year)	Assessment	Sample	Size	Prevalence (%)	Included as variables		
					Angle classification	Sex	Age
Suhr et al. ⁷ (1984)	Angle classification	7–22 year old students in Seoul	8,989	61	Yes	Yes	Yes
Sohn et al. ⁸ (1993)	HLD, TPI, and HMAR	Elementary students from Seoul, Gwangju, Hwasun, and Anyang	649	Not applicable	No	Yes	No
Kwon et al. ⁹ (1989)	Angle classification	Kyungpook National University Dental Hospital	1,795	Not applicable	Yes	Yes	Yes
Yang ¹⁰ (1995)	Angle classification	Seoul National University Dental Hospital	6,788	Not applicable	Yes	Yes	Yes
Baik et al. ¹¹ (1995)	Angle classification	Yonsei University Dental Hospital	2,155	Not applicable	Yes	Yes	Yes
Yu et al. ¹² (1999)	Angle classification	Yonsei University Dental Hospital	9,159	Not applicable	Yes	Yes	Yes
Hwang et al. ¹³ (2001)	Angle classification	Chosun University Dental Hospital	3,070	Not applicable	Yes	Yes	Yes
Im et al. ¹⁴ (2003)	Angle classification	Seoul National University Dental Hospital	676	Not applicable	Yes	Yes	Yes
Chung and Lee ¹⁵ (2006)	Angle classification	Yeungnam University Hospital	993	Not applicable	Yes	Yes	Yes
Yoon ¹⁶ (2008)	Angle classification	Dankook University Dental Hospital	4,043	Not applicable	Yes	Yes	Yes
Jung ¹⁸ (2009)	Angle classification	Private clinics	1,620	Not applicable	Yes	Yes	Yes
Piao et al. ¹⁷ (2016)	Angle classification	Yonsei University Dental Hospital	7,476	Not applicable	Yes	Yes	Yes
Choi ¹⁹ (2017)	Angle classification	Private clinic	1,254	Not applicable	Yes	Yes	Yes
This study	Subjective assessment	Nationwide sample	165,996	18.7	No	Yes	Yes

HLD, Handicapping labiolingual deviation; TPI, treatment priority index; HMAR, handicapped malocclusion assessing record.

treatment required. Therefore, in the early and late mixed dentition period (E1 and E4), growth modification of skeletal malocclusion and interceptive/preventive orthodontic treatment for dental malocclusion should be considered. However, in the early permanent dentition and permanent dentition periods (M1 and H1), one out of four to five students showed malocclusion. This could be attributed to the following reasons: (1) skeletal malocclusion worsens with age, and (2) dental dysplasia, such as protrusion, abnormal overjet, and deep/open bite are apparent in the development of the permanent dentition.

Changes in the prevalence of malocclusion according to sex

In the present study, the female group showed a

dominant pattern in the prevalence of malocclusion over the male group in each grade group, regardless of year (19.6% vs.16.5%, $p < 0.0001$; Table 2). However, Suhr et al.⁷ reported no significant difference in malocclusion prevalence between males and females among 7- to 22-year-old Korean students. This variance might be due to differences in the assessment methods and geographic regions: Suhr et al.⁷ considered the sum of cases showing Angle’s class I (45.7%), II (7.6%), and III (7.9%) as those requiring orthodontic treatment and conducted their study in a single community (Seoul); in contrast, this study considered the sum of those categorized as “N-OTx” and “U-OTx” as those requiring orthodontic treatment and was conducted nationwide.

Table 4. Suggested criteria for malocclusion assessment

Component		Assessment criteria		
	History of previous orthodontic treatment	Removable appliance	Extraoral appliance	Fixed appliance
Facial	Profile	Convex	Straight	Concave
	Facial type	Brachy	Meso	Dolicho
	Asymmetry	Symmetry	Asymmetry	-
	Nasolabial angle	Obtuse	Normal	Acute
Dental	Antero-posterior relationship	Class I	Class II	Class III
	Anterior crossbite	Yes	No	
	Vertical relationship	Open	Normal	Deep
	Posterior crossbite	Unilateral crossbite	Normal	Unilateral scissor bite
		Bilateral crossbite		Bilateral scissor bite
Arch length discrepancy	Crowding	Normal	Spacing	
Upper incisor	Labioversion	Normal	Linguoversion	
Lower incisor	Labioversion	Normal	Linguoversion	

Suggestion of new assessment method for Korean oral health examination

The main objectives of malocclusion assessment in oral health examinations are to screen patients who may potentially require orthodontic treatment and to recommend appropriate orthodontic treatment methods and appliances depending on their malocclusion types. However, the current malocclusion assessment method in Korean oral health examinations (Figure 1) has some limitations as follows: (1) Since individual occlusal development stage can vary even within the same grade or age, it is necessary to obtain actual examination recordings or radiographic images of the sample when obtaining the secondary data set. (2) It cannot explain the malocclusion types including the skeletal or dental origin. (3) It cannot reveal the specific reasons underlying the need of orthodontic treatment. (4) When the subjects who received orthodontic treatment previously might have unsolved problems, unfavorable growth potential, or relapse, it is necessary to decide whether they should be classified as “N-M” or “N-OTx.”

Alajlan et al.²⁶ classified the malocclusion type in a clinically simple and practical manner: openbite, crossbite, and scissor bite. Therefore, it is necessary to revise the oral health examination form to allow classification of the problems or malocclusion types. Thus, we would like to propose additions to the oral health examination form to obtain further information (Table 4). The revised oral health examination form consists of three major components, which are “History of previous orthodontic treatment,” including “Facial” and “Dental”; “History of previous orthodontic treatment,” including removable, extraoral, or fixed appliance; “Facial component” include “Profile,” “Facial type,” “Asymmetry,” and

“Nasolabial angle”; and “Dental component” including “Antero-posterior relationship,” “Anterior crossbite,” “Vertical relationship,” “Posterior crossbite,” “Arch length discrepancy,” and “inclination of the upper and lower incisors.” Therefore, after examiners check all the components comprehensively and rule them out one by one, they can refer their examinee to the specialists at an appropriate time. Appropriate timely referral is critical for the success of orthodontic treatment. In addition, use of cephalometric or panoramic radiographs can increase the reliability of malocclusion assessment.

Although the absolute demand for orthodontic treatment in the growing children population in Korea might decrease in the next few decades, the orthodontic treatment needs for adults and/or elderly people population might increase due to concerns over facial and dental esthetics. Therefore, nationwide examinations including assessment of malocclusion types and orthodontic treatment needs of adults should be considered in future studies.

CONCLUSION

Although significant information about the prevalence of malocclusion could be obtained from nationwide oral health examinations, further studies are necessary to modify the malocclusion assessment methods for providing specific type of malocclusion data in pre-adolescent and adolescent students.

CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

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