



Prevalence and Factors Associated with Dentofacial Characteristics of Malocclusion among Saudi Adults: A Cross-Sectional Study

Abed Al-Hadi Hamasha^{1,2,*}, Hind A. Alfehaid², Nouf A. Alqahtani², Sarah A. Alhusseini², Rasha K. Alomar², Nouf A. Almayouf², Norah F. Aljuhaimi² and Atheer A. Almasoud²

¹ Department of Preventive Dentistry, Jordan University of Science and Technology, Irbid, Jordan

² Preventive Dental Science Department, College of Dentistry, King Saud bin Abdulaziz University for Health Sciences, Riyadh, Saudi Arabia

*Corresponding e-mail: hamasha@just.edu.jo

ABSTRACT

Objectives: The study aimed to explore the prevalence of malocclusion characteristics in Saudi adults. **Methods:** A cross-sectional study was designed to examine 350 adult patients attending King Abdulaziz Medical City of the National Guard Health Affairs. Data were obtained by self-reported questionnaires and clinical dental examinations. Questionnaires comprised of sociodemographic and oral habits. The clinical dental examination was based on the Basic Methods of the World Health Organization criteria for dentofacial anomalies (1997). Statistical analyses included descriptive statistics, chi-square tests, and binary logistic regression analysis. **Results:** Regarding oral habits; 6% reported thumb sucking, 11% tongue thrusting, 42% mouth breathing and 5.7% had speech problems. The prevalence of dentofacial characteristics of malocclusion was found as follows: 41.5% had crowded in the anterior teeth, 31.4% had spacing in the anterior teeth, 16.6% had Diastema, 49.7% had teeth irregularities, 42.5% had overjet, 18.3% had anterior crossbites and 31.1% had anterior open bite. The risk indicators for crowding were age and gender; for spacing were education, tongue thrusting, and speech problem; for Diastema was education; for teeth irregularities was mouth breathing; and for crossbite were thumb sucking, tongue thrusting and mouth breathing. No risk indicators were associated with anterior overjet and open bite. **Conclusion:** The prevalence of dentofacial characteristics of malocclusion ranged from 17-50%. The prevalence of oral habits that might cause malocclusion varied from 6% to 44%. Age, gender, education, tongue thrusting, speech problem, mouth breathing; and thumb sucking were risk indicators for malocclusion characteristics.

Keywords: Characteristics, Dentofacial, Malocclusion, Prevalence, Saudi

INTRODUCTION

The prevalence of dentofacial characteristics of malocclusion in the community setting is essentially important in providing statistics on the size of the oral health problems and its public health significance [1]. Reviewing the dental literature related to malocclusion in Saudi Arabia revealed that many of the published articles used Angel's classification to describe the prevalence of malocclusion, which is suitable only in clinical settings [2-4]. Some studies used dental aesthetic index (DAI), however this index is useful in determining the orthodontic treatment needs [5].

The present study is the first in Saudi Arabia to address the prevalence of dentofacial characteristics of malocclusion among adults in the community setting using the World Health Organization (WHO) Oral Health survey basic methods [6]. This index is beneficial in assessing dentofacial characteristics proposed by the WHO including crowding and spacing in the anterior segment, Diastema, anterior maxillary, and mandibular overjet, open bite and anterior-posterior relation.

Malocclusion in children was reported in a few studies in Saudi Arabia. Albakri, et al., [2]. has studied malocclusion among children aged 12-15 years in Riyadh city. They found that the prevalence of crowding in anterior region was 23-28% and spacing was 9-11% [2]. However, older study had reported the prevalence of crowding in 4-6 years old

children as 14.7% [7]. In another Saudi study of adolescents in the North Border of Saudi Arabia, 47% were having crowding, 27% spacing, 22% excessive overjet, and about 5% were having either anterior crossbite or anterior open bites [4].

The prevalence of crowding in anterior teeth was reported as 47.3% using Saudi dental records of patients who attended one orthodontic clinic [8]. No single Saudi study was found to address malocclusion among adults. In addition no study with comprehensive dentofacial characteristics of malocclusion was found in Saudi Arabia.

Most of the dentofacial anomalies are inherited conditions which can pass from parents to siblings, however many other conditions have played important roles in creating malocclusion [9]. These conditions included habits like thumb sucking, tongue thrusting, mouth breathing, speech Problem. Subjects' demographics were also important factors [10-12].

The effect of demographics, habits and other conditions on dentofacial characteristics of malocclusion among Saudi adults was not studied. Therefore the aim of the present study is to explore the prevalence of malocclusion characteristics in Saudi adults using WHO index and to assess the simultaneous effect of demographic, thumb sucking, tongue thrusting, mouth breathing, speech problem on the malocclusion.

MATERIALS AND METHODS

The present study comprised a cross-sectional observational analytical study of the prevalence of dentofacial characteristics among adults in Riyadh, Saudi Arabia. The rights of the human subjects were protected and approval was obtained from the IRB of King Abdullah International Medical Research Center (KAIMRC), (IRB/SP18/315/R). Participants were asked to sign a consent form before the interviews and clinical examination.

The study was conducted in the waiting areas of King Abdulaziz Medical City of the National Guard Health Affairs. The data was collected in two months' duration between August and October of 2018. Eligible subjects were all adult patients and their companions who were waiting for their appointment in the outpatients clinics. No attempt was made to select or exclude any participant in these waiting areas. Exclusion criteria included subjects who had previous orthodontic treatment or orthognathic surgery, those who retained primary teeth and subjects with systemic syndromes.

The sample size was calculated by online sample size calculator for Confidence Level of 0.95% and Confidence Interval of 5 for a population of about 3000 subjects. The sample size needed for this study was 341 participants.

The study was conducted using self-reported questionnaires and clinical dental examinations. Questionnaires were prepared to include the following sections: A) Socio-demographic data, including age, gender, nationality, education, and income. B) Oral habits, including thumb sucking, tongue thrusting, mouth breathing, and speech problems. The questionnaire was tested using a pilot sample of 20 dental patients who were asked to provide feedback with comments about the questions. Necessary alterations of the questionnaire were made accordingly.

The outcome of the clinical dental examinations was recorded on examination assessment sheets. Clinical examinations were performed by two senior dental students from the College of Dentistry, KSAUHS. Both examiners were calibrated on the examination criteria by a senior faculty member, and inter-examiner reliability was also calculated.

The oral examinations were conducted using portable regular chairs with headrests and illumination which was gained using natural and/or artificial light. Sterilized dental mirrors, standard periodontal probes, and wooden tongue depressors were used by examiners while they were wearing disposable gloves and masks. The clinical dental examination was based on the criteria of Basic Methods of the World Health Organization (WHO) of dentofacial anomalies [6]. The following dentofacial characteristics were included in the examinations: 1) Crowding in the incisal segments 2) Spacing in the incisal segment 3) Diastema 4) irregularities in the maxillary and mandibular anterior teeth 5) anterior maxillary overjet 6) anterior mandibular overjet 7) vertical anterior open bite and 8) anteroposterior molar relations. All occlusal relationships were assessed at a centric occlusion position, which was achieved by asking the subject to swallow and then to bite in his or her most posterior teeth.

SPSS statistical program version 23 (IBM Inc. NY, USA) was used for entering, cleaning and analyzing the data. Statistical analyses included descriptive statistics, chi-square tests, and binary logistic regression analysis. Chi square

tests were used to compare the prevalence of dentofacial malocclusion characteristics among different genders. Binary Logistic Regression analysis was used to assess the simultaneous impact of age, gender, education, income, and oral habits on the dentofacial characteristics of malocclusion. A probability value of 0.05 or less was considered significant and Odd Ratio and Confidence Interval of 95% were evaluated.

RESULTS

Table 1 presented the frequency distribution of demographic characteristics and oral habits related to dentofacial characteristics. The mean age of participants was 34 years ranging from 18 years to 70 years. About 70% of the participants were females, only 39% of the subjects were highly educated with bachelor degrees and above. The proportion of participants with income about the average national income and below income was 54%. Regarding oral habits that might affect dentofacial characteristics, only 6% were found to have thumb sucking and 11% with tongue thrusting. Moreover, about 42% reported that they have mouth breathing. Most of the participants said that they don't have speech problems (5.7%).

Table 1 Frequency distribution of participants among demographic characteristics and oral habits related to malocclusion

Variable	Category	No. (%)	Total
Gender	Male	105 (30.0%)	350
	Female	245 (70.0%)	
Educational Qualification	Illiterate	18 (5.2%)	349
	Primary school	19 (5.4%)	
	Intermediate school	39 (12.2%)	
	High school	136 (39.0%)	
	Bachelor degree	125 (35.8%)	
	Postgraduate degree	12 (3.4%)	
Monthly Income	Less than SR9000	145 (41.9%)	346
	SR9000-SR12000	43 (12.4%)	
	SR12100-SR15000	36 (10.4%)	
	More than 15000	122 (35.3%)	
Thumb sucking	Yes	21 (6.0%)	350
	No	329 (94.0%)	
Tongue thrusting	Yes	38 (10.9%)	350
	No	312 (89.1%)	
Mouth breathing	Yes	153 (43.8%)	349
	No	196 (56.2%)	
Speech problems	Yes	20 (5.7%)	349
	No	329 (94.3%)	

Table 2 presented the gender-specific prevalence of certain dentofacial characteristics among Saudi participants. Crowding in the anterior teeth was observed in about 46% of females and 32% of males, and the difference was statistically significant ($p=0.023$). Additionally, the prevalence of spacing in the anterior teeth was higher among males (36.2) than in females (29.3). However, the difference was not statistically significant ($p=0.21$). Normal Diastema was observed in 286 participants. The presence of Diastema was observed in 18.8% of male participants compared to 15.7% of female participants ($p=0.053$). The presence of teeth irregularities was detected in 49.7% of participants, with no significant difference between males and females ($p=0.85$). Normal anterior Maxillary overjet was detected in about 57.5% of participants. About 34% of participants exhibited mild increase in overjet with additional 8% had moderate and severe increase in overjet. Normal overjet was observed more in females (59%) compared to males (54%) but the difference was not significant ($p=0.72$). Normal crossbite (anterior mandibular overjet) was observed in 83.3% of females and 78% of males. Of the 64 subjects (18.3%) with anterior crossbite, 22% were males and 17% were females. Anterior open bite, which represents >2 mm, was observed in 31% of participants. About 37% of males were presented with anterior open bite compared to 28.6% in females, however, the difference was not statistically significant ($p=0.11$).

Table 2 Gender specific prevalence of certain dentofacial characteristics among Saudi participants

Variable	Category	Male		Female		Both		χ^2	p-value
		N	%	N	%	N	%		
Crowding in anterior teeth	Present	34	32.4%	110	45.5%	144	41.5%	5.15	0.023*
	Absent	71	67.6%	132	54.5%	203	58.5%		
Spacing in anterior teeth	Present	38	36.2%	71	29.3%	109	31.4%	1.6	0.207
	Absent	67	63.8%	171	70.7%	238	68.6%		
Median Diastema	0-1 mm (Ideal)	82	81.2%	204	84.3%	286	83.4%	7.7	0.053
	2-3 mm (mild)	16	15.8%	37	15.3%	53	15.5%		
	4-6 mm (moderate)	3	3%	0	0%	3	0.9%		
	6 mm (severe)	0	0%	1	0.4%	1	0.3%		
Teeth irregularities	Present	53	50.5%	121	49.4%	174	49.7%	0.35	0.852
	Absent	52	49.5%	124	50.6%	176	50.3%		
Anterior Maxillary overjet	1-2 mm (normal)	51	54.3%	132	58.9%	183	57.5%	1.36	0.716
	3-4 mm (mild)	35	37.2%	74	33%	109	34.3%		
	5-6 mm (moderate)	7	7.4%	13	5.8%	20	6.3%		
	>6mm (severe)	1	1.1%	110	2.2%	6	1.9%		
Anterior crossbite	Normal	82	78.1%	204	83.3%	286	81.7%	2.59	0.275
	Single tooth	12	11.4%	27	11%	39	11.1%		
	Multiple teeth	11	10.5%	14	5.7%	25	7.1%		
Anterior open bite	0 mm normal	175	71.4%	66	62.9%	241	68.9%	3.75	0.29
	1-2 mm (mild)	62	25.3%	33	31.4%	95	27.1%		
	3-4 mm (moderate)	5	2%	5	4.8%	10	2.9%		
	>4 mm (severe)	3	1.2%	1	1%	4	1.1%		

*Statistically significant using Chi square tests

The relationship between demographic characteristics and oral habits in relation to crowding in the anterior teeth among participants using binary logistic regression analysis was presented in Table 3. Younger age group (odds ratio [OR]=1.52) and females (odds ratio [OR]=1.88) presented significant odds of predicting crowding in anterior teeth.

Table 3 Demographic characteristics and oral habits in relation to crowding in the anterior teeth among participants using Binary Logistic Regression analysis

Variables	B	S.E.	p-value	Exp(B)	95% C.I. for EXP(B)	
					Lower	Upper
Age	0.42	0.14	0	1.52	1.16	1.98
Gender	0.63	0.26	0.01	1.88	1.15	3.01
Education	0.2	0.11	0.08	1.22	0.98	1.52
Monthly Income	0.13	0.09	0.17	1.13	0.95	1.36
Thumb Sucking	0.28	0.49	0.57	1.32	0.5	3.47
Tongue Thrusting	0.24	0.39	0.53	1.28	0.6	2.74
Mouth Breathing	0.1	0.23	0.68	1.1	0.7	1.73
Speech Problem	0.31	0.48	0.52	0.73	1.37	3.52
Constant	0.46	0.63	0.47	1.58		

B: Regression coefficient; S.E.: Standard Error; Exp(B): Odd Ratio; C.I.: Confidence Interval

Table 4 presented the relationship between demographic characteristics and oral habits in relation to spacing in the anterior teeth among participants using binary logistic regression analysis. Illiterate subjects (odds ratio [OR]=1.34), subjects with tongue thrusting (odds ratio [OR]=2.24) and subjects with speech problems (odds ratio [OR]=4.92) had significant odd of predicting spacing in the anterior teeth.

Table 4 Demographic characteristics and oral habits in relation to Spacing in the anterior teeth among participants using Binary Logistic Regression analysis

Variables	B	S.E.	p-value	Exp(B)	95% C.I. for EXP(B)	
					Lower	Upper
Age	0.28	0.15	0.06	1.33	0.99	1.77
Gender	0.47	0.27	0.08	1.6	1.15	3.01
Education	0.3	0.11	0.01	1.34	0.98	1.52
Monthly Income	0.01	0.1	0.9	1.01	0.95	1.36
Thumb Sucking	0	0.54	1	1	0.5	3.47
Tongue Thrusting	0.81	0.4	0.05	2.24	1.02	4.93
Mouth Breathing	0.05	0.25	0.83	1.06	0.65	1.72
Speech Problem	1.59	0.78	0.04	4.92	1.37	3.52
Constant	0.28	0.15	0.06	1.09		

B: Regression coefficient; S.E.: Standard Error; Exp(B): Odd Ratio; C.I.: Confidence Interval

Binary logistic regression analysis was also conducted between the presence of diastema and some demographic variables and oral habits (Table 5). The only factor that was found related is diastema was subjects with less education (odds ratio [OR]=1.4).

Table 5 Demographic characteristics and oral habits in relation to Diastema in the anterior teeth among participants using Binary Logistic Regression analysis

Variables	B	S.E.	p-value	Exp (B)	95% C.I. for EXP(B)	
					Lower	Upper
Age	0.25	0.19	0.17	1.29	0.9	1.85
Gender	0.32	0.33	0.33	1.38	0.72	2.63
Education	0.33	0.14	0.02	1.4	1.06	1.83
Monthly Income	0.07	0.12	0.55	1.07	0.85	1.36
Thumb Sucking	0.27	0.67	0.69	1.31	0.35	4.85
Tongue Thrusting	0.57	0.43	0.18	1.78	0.76	4.14
Mouth Breathing	0.2	0.31	0.51	1.23	0.67	2.23
Speech Problem	0.39	0.68	0.57	1.48	0.39	5.62
Constant	0.43	0.85	0.61	1.54		

B: Regression coefficient; S.E.: Standard Error; Exp(B): Odd Ratio; C.I.: Confidence Interval

Tables 6 and 7 presented the relationship between demographic characteristics and oral habits in relation to teeth irregularities and overjet in the anterior teeth, respectively. The only variable that was found significantly related was mouth breathing in relation to teeth regularities (odds ratio [OR]=1.72). No other variable was found predicting the presence of overjet or teeth irregularities.

Table 6 Demographic characteristics and oral habits in relation to teeth irregularities in the anterior teeth among participants using Binary Logistic Regression analysis

Variables	B	S.E.	p-value	Exp (B)	95% C.I. for EXP(B)	
					Lower	Upper
Age	0.12	0.13	0.36	1.13	0.87	1.46
Gender	0.03	0.24	0.9	1.03	0.64	1.66
Education	0.07	0.1	0.5	1.07	0.88	1.32
Monthly Income	0.02	0.09	0.84	1.02	0.86	1.21
Thumb Sucking	0.07	0.48	0.89	1.07	0.41	2.76
Tongue Thrusting	0.43	0.38	0.26	1.54	0.73	3.23
Mouth Breathing	0.54	0.23	0.02	1.72	1.11	2.67
Speech Problem	0.51	0.5	0.31	1.66	0.63	4.39
Constant	0.45	0.61	0.47	1.57		

B: Regression coefficient; S.E.: Standard Error; Exp(B): Odd Ratio; C.I.: Confidence Interval

Table 7 Demographic characteristics and oral habits in relation to overjet in the anterior teeth among participants using Binary Logistic Regression analysis

Variables	B	S.E.	p-value	Exp (B)	95% C.I. for EXP(B)	
					Lower	Upper
Age	0.07	0.14	0.6	1.07	0.82	1.4
Gender	0.16	0.25	0.53	1.17	0.71	1.93
Education	0.14	0.11	0.22	1.15	0.92	1.43
Monthly Income	0.04	0.09	0.64	1.04	0.87	1.25
Thumb Sucking	0.3	0.55	0.58	1.36	0.46	3.97
Tongue Thrusting	0.16	0.39	0.68	1.17	0.55	2.51
Mouth Breathing	0.04	0.24	0.88	1.04	0.65	1.65
Speech Problem	0.03	0.5	0.96	1.03	0.38	2.74
Constant	0.84	0.64	0.19	2.32		

B: Regression coefficient; S.E.: Standard Error; Exp(B): Odd Ratio; C.I.: Confidence Interval

The relationship between demographic characteristics and oral habits in relation to crossbite and open bite in the anterior teeth using binary logistic regression analysis was presented in Tables 8 and 9. Subjects with thumb sucking, tongue thrusting, and mouth breathing had significant odd of predicting crossbites in the anterior teeth (odds ratio [OR]=6.94, 2.47 and 1.89, respectively). No significant factors were found related to open bite in the anterior teeth.

Table 8 Demographic characteristics and oral habits in relation to crossbite in the anterior teeth among participants using Binary Logistic Regression analysis

Variables	B	S.E.	p-value	Exp(B)	95% C.I. for EXP(B)	
					Lower	Upper
Age	0.11	0.18	0.56	1.11	0.78	1.59
Gender	0.41	0.32	0.2	1.5	0.8	2.81
Education	0.05	0.14	0.7	1.06	0.8	1.39
Monthly Income	0.05	0.12	0.66	1.06	0.83	1.34
Thumb Sucking	1.94	0.52	0	6.94	2.51	19.18
Tongue Thrusting	0.91	0.43	0.04	2.47	1.06	5.76
Mouth Breathing	0.64	0.3	0.04	1.89	1.05	3.41
Speech Problem	1.26	0.83	0.13	3.53	0.7	17.86
Constant	1.67	0.85	0.05	5.32		

B: Regression coefficient; S.E.: Standard Error; Exp(B): Odd Ratio; C.I.: Confidence Interval

Table 9 Demographic characteristics and oral habits in relation to open bite in the anterior teeth among participants using Binary Logistic Regression analysis

Variables	B	S.E.	p-value	Exp (B)	95% C.I. for EXP(B)	
					Lower	Upper
Age	0.24	0.14	0.1	1.27	0.96	1.68
Gender	0.48	0.26	0.06	1.61	0.98	2.66
Education	0.03	0.11	0.81	1.03	0.83	1.27
Monthly Income	0.03	0.1	0.75	1.03	0.85	1.24
Thumb Sucking	0.52	0.49	0.29	1.68	0.65	4.39
Tongue Thrusting	0.28	0.39	0.47	1.32	0.62	2.81
Mouth Breathing	0.37	0.24	0.12	1.45	0.9	2.32
Speech Problem	0.09	0.5	0.87	1.09	0.41	2.9
Constant	1.03	0.66	0.12	2.79		

B: Regression coefficient; S.E.: Standard Error; Exp(B): Odd Ratio; C.I.: Confidence Interval

DISCUSSION

The prevalence of dentofacial characteristics of malocclusion was observed as the following: 49.7% had teeth irregularities, 43% had anterior overjet, 42% had crowding, 31% had either spacing or anterior open bites, 18% had anterior crossbites and 17% had diastemas. Regarding oral habits that might affect dentofacial characteristics, mouth breathing was observed in 44% of subjects followed by tongue thrusting (11%) and thumb sucking (6%) and speech problems (5.7%). The binary logistic regression analyses revealed that the risk indicators for crowding were age and gender; for spacing were education, tongue thrusting, and speech problem; for Diastema were education; for teeth irregularities were mouth-breathing; and for crossbite were thumb sucking, tongue thrusting and mouth breathing. No risk indicators were associated with anterior overjet and open bite.

Most of the published studies addressed the prevalence of malocclusion in Saudi Arabia used Angel's classification [2,4,13,14]. This Index was not intended to assess malocclusion in the community settings, rather give percentage of population class I to III. Using this classification, many occlusal characteristics will be ignored. Yet our study is the first in Saudi Arabia to measure the prevalence of malocclusion characteristics using the WHO index [6].

Reviewing the current dental literature of malocclusion, most of these studies were designed to address malocclusion in children or adolescents. Additionally, most of these studies investigated only the prevalence of malocclusion, but not related risk markers of determinants [2,7]. The present study is different in addressing malocclusion in adults (untreated malocclusion) in addition; it investigated the risk indicators associated with each malocclusion characteristic from demographics and oral habits that are considered confounding factors of malocclusion.

Crowding in the anterior teeth was found in about 46% among our subjects, this result was comparable to some previous studies [15,16]. However, a study from Colombia reported a higher prevalence of anterior crowding [17]. Spacing in the anterior teeth was observed in 29% of Saudi adults. These results are consistent with another finding, though most studies were considered spacing in the anterior and posterior teeth as one component [4,18]. Diastema was reported in two previous studies with a prevalence of about 22%. However, Diastema in our sample was presented in about 15%. This might be explained that children's Diastema might decrease by increasing age [15,18].

About 43% of Saudi subjects exhibited increased overjet in their anterior teeth, which is comparable to Iranian [19], Turkish [20], German [21], and Indian [22]. However, Italians had a lower prevalence of overjet (4.1%-16.2%) [15]. This difference was not surprising since they considered an increase of overjet up to 4 mm as normal overjet. In Saudi Arabia, two studies were found with contrasting results [8,23]. The anterior crossbite was observed in 18% of our sample which was higher than the rates observed by other studies [21,24]. The method of recording the findings played an important role in this difference. Crossbite was considered present in our study if a single tooth was recorded. The anterior open bite was also similar to the rates reported in other studies [15,18,22].

The results of the present study showed that about 40%-50% of adults had teeth irregularities, increased anterior overjet, and crowding. This indicated the need for awareness of citizens and their primary dental care practitioners to dentofacial anomalies and that can be avoided by promoting interceptive orthodontic treatment or early corrective orthodontics before reaching adulthood. About 8% of adults had anterior overjet higher than 5mm. Treatment of such cases overjet in this group of adults will prevent further trauma of their anterior teeth.

One of the limitations of our study was that the sample was not random. Since participants were adults, Saudi adults are not approachable to their homes. This is the best way to draw a sample from patients attending medical appointments not related to dentistry. Additionally most of the participants were females since it is drawn from outpatient clinics.

CONCLUSION

The prevalence of dentofacial characteristics of malocclusion ranged from 17-18% for diastemas and anterior crossbites to 31% for spacing or anterior open bites to more than 40% for crowding, overjet and teeth irregularities. The prevalence of oral habits that might cause malocclusion varied from 6% for thumb sucking and speech problem to 44% for mouth breathing. Among several demographic and oral habits that might affect occlusion, the risk indicators for crowding were age and gender, for spacing was education, tongue thrusting, and speech problem, for diastema were education; for teeth irregularities were mouth-breathing; and for crossbite were thumb sucking, tongue thrusting and mouth breathing.

DECLARATIONS

Funding Source

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflicts of Interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

REFERENCES

- [1] Alhammadi, Maged Sultan, et al. "Global distribution of malocclusion traits: A systematic review." *Dental Press Journal of Orthodontics*, Vol. 23, No. 6, 2018, pp. e1-10.
- [2] Albakri, Fahad M., Navin Ingle, and Mansour K. Assery. "Prevalence of malocclusion among male school children in Riyadh city." *Open Access Macedonian Journal of Medical Sciences*, Vol. 6, No. 7, 2018, pp. 1296-99.
- [3] Alkhadra, Thamer. "Characteristics of malocclusion among Saudi special need group children." *Journal of Contemporary Dental Practice*, Vol. 18, No. 10, 2017, pp. 959-63.
- [4] Gudipaneni, Ravi Kumar, et al. "The prevalence of malocclusion and the need for orthodontic treatment among adolescents in the northern border region of Saudi Arabia: An epidemiological study." *BMC Oral Health*, Vol. 18, No. 1, 2018, p. 16.
- [5] AlQarni, Mohammed Ali, et al. "Evaluate the malocclusion in subjects reporting for orthodontic treatment among Saudi population in Asser Region." *Journal of International Oral Health*, Vol. 6, No. 4, 2014, pp. 42-46.
- [6] World Health Organization. "Oral Health Surveys-Basic Methods." 4th edn. Geneva: World Health Organization; 1997.
- [7] Alamoudi, N. "The prevalence of crowding, attrition, midline discrepancies and premature tooth loss in the primary dentition of children in Jeddah, Saudi Arabia." *The Journal of Clinical Pediatric Dentistry*, Vol. 24, No. 1, 1999, pp. 53-58.
- [8] Baeshen, Hosam. "The prevalence of major types of occlusal anomalies among Saudi Middle school students." *The Journal of Contemporary Dental Practice*, Vol. 18, No. 2, 2017, pp. 142-46.
- [9] Aznar, T., et al. "Dental arch diameters and relationships to oral habits." *The Angle Orthodontist*, Vol. 76, No. 3, 2006, pp. 441-45.
- [10] Kolawole, K. A., et al. "Oral habits and malocclusion in children resident in Ile-Ife Nigeria." *European Archives of Paediatric Dentistry*, Vol. 20, No. 3, 2019, pp. 257-65.
- [11] Fraga, Wanderson S., et al. "Mouth breathing in children and its impact in dental malocclusion: A systematic review of observational studies." *Minerva Stomatologica*, Vol. 67, No. 3, 2018, pp. 129-38.
- [12] Fraser, C. "Tongue thrust and its influence in orthodontics." *International Journal of Orthodontics (Milwaukee, Wis.)*, Vol. 17, No. 1 2006, pp. 9-18.
- [13] Aldrees, Abdullah M. "Pattern of skeletal and dental malocclusions in Saudi orthodontic patients." *Saudi Medical Journal*, Vol. 33, No. 3, 2012, pp. 315-20.
- [14] Bhayat, A., and M. S. Ahmad. "Oral health status of 12-year-old male schoolchildren in Medina, Saudi Arabia." *EMHJ-Eastern Mediterranean Health Journal*, Vol. 20, No. 11, 2014, pp. 732-37.
- [15] Perillo, Letizia, et al. "Prevalence of orthodontic treatment need in southern Italian schoolchildren." *The European Journal of Orthodontics*, Vol. 32, No. 1, 2009, pp. 49-53.
- [16] Nobile, Carmelo GA, et al. "Prevalence and factors related to malocclusion and orthodontic treatment need in children and adolescents in Italy." *European Journal of Public Health*, Vol. 17, No. 6, 2007, pp. 637-41.
- [17] Thilander, Birgit, et al. "Prevalence of malocclusion and orthodontic treatment need in children and adolescents

- in Bogota, Colombia. An epidemiological study related to different stages of dental development.” *European Journal of Orthodontics*, Vol. 23, No. 2, 2001, pp. 153-68.
- [18] Migale, D., et al. “Oral health and malocclusion in 10-to-11 years-old children in southern Italy.” *European Journal of Paediatric Dentistry*, Vol. 10, No. 1, 2009, pp. 13-18.
- [19] Atashi, Mohammad Hossein Ahangar. “Prevalence of malocclusion in 13-15 year-old adolescents in Tabriz.” *Journal of Dental Research, Dental Clinics, Dental Prospects*, Vol. 1, No. 1, 2007, pp. 13-18.
- [20] Bilgic, Fundagul, Ibrahim Erhan Gelgor, and Ahmet Arif Celebi. “Malocclusion prevalence and orthodontic treatment need in central anatolian adolescents compared to European and other nations’ adolescents.” *Dental Press Journal of Orthodontics*, Vol. 20, No. 6, 2015, pp. 75-81.
- [21] Tausche, Eve, Olaf Luck, and Winfried Harzer. “Prevalence of malocclusions in the early mixed dentition and orthodontic treatment need.” *The European Journal of Orthodontics*, Vol. 26, No. 3, 2004, pp. 237-44.
- [22] Singh, Sarabjeet, et al. “The prevalence of malocclusion and orthodontic treatment needs in school going children of Nalagarh, Himachal Pradesh, India.” *Indian Journal of Dental Research*, Vol. 27, No. 3, 2016, pp. 317-22.
- [23] Hassan, Ali H. “Orthodontic treatment needs in the western region of Saudi Arabia: A research report.” *Head and Face Medicine*, Vol. 2, No. 1, 2006, p. 2.
- [24] Sidlauskas, Antanas, and Kristina Lopatiene. “The prevalence of malocclusion among 7-15-year-old Lithuanian schoolchildren.” *Medicina*, Vol. 45, No. 2, 2009, pp. 147-52.