Distribution of Different Skeletal and Dental Relations Among Orthodontic Patients in Recent 5 Years: A Retrospective Study

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Abstract

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Keywords

Malocclusion; Skeletal relation; Angle's classification.

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Distribution of Different Skeletal and Dental Relations Among Orthodontic Patients in Recent 5 Years: A Retrospective Study

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ABSTRACT

The prevalence of malocclusion differs significantly from race to race. The cause of malocclusion could be multifactorial. Previous studies have demonstrated quantitative information on skeletal and dental relations in different countries. This study focuses on patients who had received orthodontic data collection and analysis in a specific medical center. Skeletal relation and Angle's dental classification of male and female were statisticized and analyzed. Skeletal relation of Class I was 45.4%, Class II was 29.5%, and Class III was 25.1%. Angle's dental classification of Class I was 39.3%; Class II was 30.8%; Class III was 29.9%. There was a statistically significant difference between the distribution of malocclusion and sex. Compared to previous studies, a similar distribution of skeletal relation is shown in oriental studies. The annual distribution trend is also investigated to provide brief information on patients attending the medical center for orthodontic inspection. Our study provides brief information on skeletal relation and Angle's dental classification, which can help set clinical training programs for residents and postgraduates. Moreover, epidemiological studies with a larger sample and further analysis are still required to obtain a more practical situation of malocclusion in the Taiwanese population. *Taiwanese Journal of Orthodontics 2023;35(3):128−135*

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INTRODUCTION

The definition of malocclusion is an incorrect relationship between the upper and lower dental arch when in occlusion. The term "malocclusion" is derived from occlusion and refers to incorrectly positioned teeth. The term was first created by Edward Angle (1855−1930),[1] who classified dental relations based on the relative positions of the maxillary and mandibular first molar.

The etiology of malocclusion is multifactorial and can be congenital, developmental, or environmental.[2] Congenital factors such as genes may influence skeletal growth, tooth size or agenesis, and tooth eruption. Developmental issues during different periods may affect different parts of the face. The cranial base is most affected during the natal period up to a few years after birth. Significant anterior and vertical growth of the midface during the first 3−4 years of life is noted.[3] Mandibular growth is likely to occur during puberty.[3] Some oral habits such as thumb sucking, mouth breathing, onychophagia, deglutition disorder, and abnormal postures may also affect occlusion.

Epidemiologically, malocclusion occurs in all ethnicities. However, the prevalence and distribution of malocclusions may vary according to race. Numerous studies have investigated the prevalence of malocclusion in different ethnic groups, including Caucasian, non-Hispanic black, non-Hispanic white, Amerindian, Nigerian, Chinese, Japanese, and Arabian populations. A Saudi Arabian study[4] reported Angle's Class I (52.8%), Angle's Class II (31.8%), and Angle's Class III (15.4%). An Indian

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study reported that Class I malocclusion was found in 67% of the studied population, Class II constituted 14% of the sample size, and Class III constituted 2%.[5] A 2001 study of the Belgian orthodontic population reported Class I (31%), Class II (63%), and Class III (6%).[6] A South Korean study in 1990 showed Class I (35.9%), Class II (14.9%), and Class III (49.1%).[7] A systematic review of malocclusion in Chinese school children from 1991 to 2018 revealed that the overall prevalence rates of Class I, Class II, and Class III malocclusions were 30.07%, 9.91%, and 4.76%, respectively.[8]

Malocclusion is considered one of the top priorities of oral health diseases by the World Health Organization[9]; it may influence occlusion, esthetics, pronunciation, and psychosocial self-confidence.[10,11] The demand for the patient seeking orthodontic treatment for malocclusion and dentofacial problems has increased in recent years.[12] The prevalence of malocclusion should be determined to measure the need for orthodontic treatment. However, no study analyzed the prevalence and distribution of malocclusion in the Taiwanese orthodontic population.

This study aims to provide a brief statistic of malocclusion and dentofacial characteristics among a sample of hospital-based Taiwanese orthodontic patients to analyze the prevalence of malocclusion and provide quantitative information.

MATERIALS AND METHODS

This retrospective study is based on medical records (including radiography examinations, study casts, and cephalometric analyses). A database of 3019 patients between July 2015 and June 2021 who attended the Orthodontic Department of Kaohsiung Medical University Hospital (KMUH) and had orthodontic data collection was included in our primary database. Patients' general information regarding chart number, sex, age at first attendance, and date of first attendance were obtained. Patients undergoing orthodontic data collection and analysis underwent clinical examination of hard and soft tissue, radiographs of the lateral and Posterior-Anterior (PA) cephalograms, panoramic films, and registration of the dental study cast.

Skeletal relations and Angle's classification were used to distribute data into groups. Skeletal relations were divided into three groups according to the norm values of SNA, SNB, and ANB degrees certified by the Taiwan Association of Orthodontists (TAO) (Table 1). Patients with ANB angle within the average value were classified as Class I. Patients with ANB angle larger than the average value were classified as Class II. ANB angle smaller than normal values were classified as Class III. Angle's classification was used to determine dental relation (Figure 1). Angle's Class I classification: The mesiobuccal cusp of the maxillary first permanent molar occludes with the mesiobuccal groove of the mandibular first permanent molar. Angle's Class II classification: The molar relationship shows that the mesiobuccal groove of the mandibular first molar is distally (posteriorly) positioned when in occlusion with the mesiobuccal cusp of the maxillary first molar. Usually, the mesiobuccal cusp of the maxillary first molar rests between the first mandibular molar and the second premolar. Angle's Class III classification: The mesiobuccal cusp of the maxillary first permanent molar occludes distally to the mesiobuccal groove of the mandibular first molar. The criteria of dental relation only depend on molar relation; British Incisor classification does not affect our sampling.

Table 1. Normal values of SNA, SNB, and ANB angle certified by Taiwan association of Orthodontists.

	Norm (<15 y/o)		Norm (>15 y/o)	
	Male	Female	Male	Female
SNA	78.92–85.22	79.1–85.62	80.59–87.45	79.72–86.1
SNB	75.81–81.71	76.27–82.43	77.76–84.1	79.72–83.7
ANB	1.53–5.11	1.2–4.76	1.4–5.02	0.7–3.8

Inclusion criteria of patients were complete medical records, orthodontic cephalometric film, and molar relation of permanent teeth that can be evaluated with dental casts. Patients who could not be assigned to any dental classification, those without sufficient information, those with permanent molars unerupted or extracted, those with Angle's normal occlusion, and those who had undergone orthodontic treatment or orthognathic surgery before were also excluded.

After being permitted by the Institutional Review Board (IRB) (KMUHIRB-E (II)-20220,150), 2471 patients were included in our final sample according to the criteria above. In the sample population aged 7–75 years, 829 (33.5%) were males and 1642 (66.5%) were females. In the age distribution, there were 192 patients under 12 years old (83 male, 109 female), 460 patients within 12–18 years old (167 male, 293 female), 1819 patients above 18 years old (579 male, 1240 female).

The distribution of skeletal patterns and Angle's classification of malocclusion were analyzed using SPSS 20.0 (IBM Corp. Released 2011. Armonk, NY: IBM Corp.). Chi-squared test was used to determine the distribution between skeletal relation and sex, Angle's dental classification and sex. Multinomial

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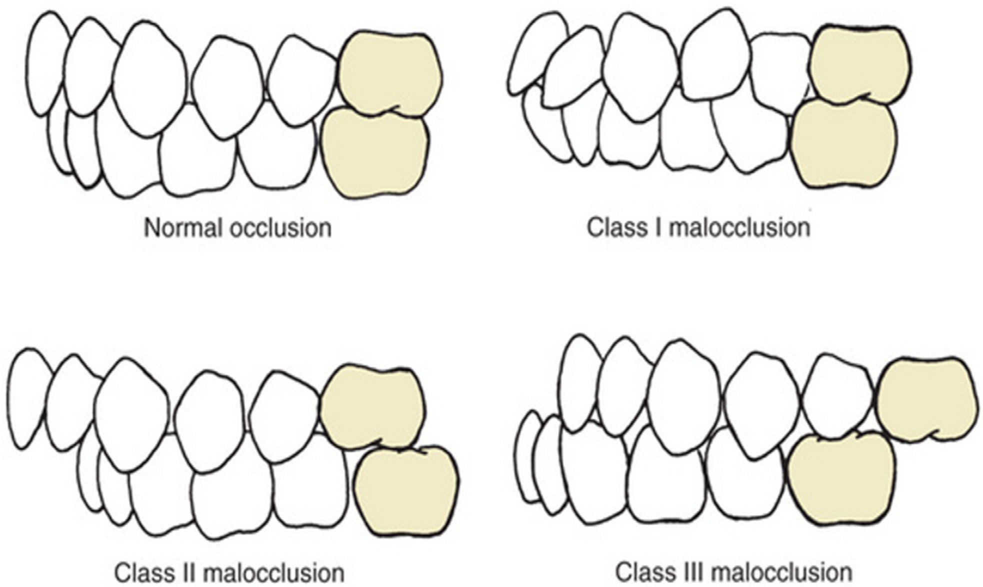

Figure. 1. Angle's classification of occlusion.[38] (From Contemporary orthodontics 6th ed, 2019, p.3).

logistic regression was used to examine the correlation of different relation groups between sex. A bivariate model with categorical variables and outcomes was applied to define a dependent variable and make predictions. A logistic regression was conducted to model the determinants and predict the likelihood of the outcome. Spearman's rho correlation test was used to evaluate the correlation between Skeletal relation and dental relation.

Table 2. Patient distribution of age and sex.

Age	Male	Female	Total
7–12	83	109	192 (7.78%)
12–18	167	293	460 (18.62%)
18–75	579	1240	1819 (73.60%)
	829	1642	2471 (100%)

RESULTS

The distribution of skeletal relationships in our data was as follows: Class I, 45.4% (345 males, 778 females); Class II, 29.5% (215 males, 513 females); and Class III, 25.1% (269 males, 351 females) (Table 2). As for Angle's classification, Angle's Class I accounts for 39.3% (287 males and 386 females). Angle's Class II accounts for 30.8% (219 males and 543 females). Angle's Class III accounts for 29.9% (323 males, 416 females) (Table 3). Chi-squared test was used to compare the three different skeletal relations between sex and three different dental relations between sex. Multinomial logistic regression was introduced to analyze the inter-sex differences between 3 different skeletal and three dental

Table 3. Patient distribution of Skeletal relation and Angle's classification.

	Skeletal Class I	Skeletal Class I	Skeletal Class I	Subtotal	Total
Male					
Angle's Class I	182	69	36	287	
Angle's Class II	79	130	10	219	
Angle's Class III	84	16	223	323	
Subtotal	345	215	269		829
Female					
Angle's Class I	453	171	59	683	
Angle's Class II	199	326	18	543	
Angle's Class III	126	16	274	416	
Subtotal	778	513	351		1642
Total					
Angle's Class I	635	240	95	970 (39.3%)	
Angle's Class II	278	456	28	762 (30.8%)	
Angle's Class III	210	32	497	739 (29.9%)	
	1123 (45.4%)	728 (29.5%)	620 (25.1%)		2471 (100%)

relations, respectively. The statistical result showed that the correlation between skeletal relation and sex, Angle's dental classification, and sex was statistically significant ($p < 0.05$). Comparing the distribution of skeletal relations between sex, skeletal Class I and skeletal Class III, skeletal Class II and skeletal Class III showed significant differences. No significant difference was shown between skeletal Class I and skeletal Class II (Table 4). Comparing the distribution of Angle's Classification between sex, Angle's Class I and Angle's Class III, Angle's Class II and Angle's Class III showed a significant difference. No significant difference was shown between Angle's Class I and Angle's Class II (Table 5).

Compare the correlation of skeletal relation and Angle's classification using Spearman's correlation in the total male and female sample. The results showed that the correlation of skeletal and dental relations was moderately correlated in the total, male and female samples (Table 6).

The annual distribution of skeletal relation and Angle's classification was listed (Table 7). The trend of skeletal relation distribution and Angle's classification distribution was shown. The number of patients having data collected from 2016 to 2021 was 475, 484, 356, 373, 447, and 336 people, respectively.

DISCUSSION

Comparing to other studies

In most present studies, skeletal jaw relation and Angle's classification were used as methods to classify patterns of malocclusion owing to their simplicity and global usage.[13] Therefore, we used these two indices to observe the prevalence and distribution of malocclusion and compared our results with those of previous studies (Table 8).[6,7,12,14–26] However, it is challenging to set the previous studies in the same standard owing to the different methods and varying standards used. Indices used to assess and record the occlusal relationships, differences in study populations, examiner subjectivity, specific objectives, and different sample sizes may have influenced on the results.[26] Sample selection, study type, and criteria such as age, race, and norms of each group also affect the consequence.

In the present study, our sample showed a prevalence of 45.4% in skeletal Class I, 29.5% in skeletal Class II, 25.1% in skeletal Class III as well as 39.3% in Angle's Class I, 30.8% in Angle's Class II, and 29.9% in Angle's Class III. Comparing our study to other studies in East Asia (Shen et al.,[14] Ota et al.,[15] Yang[7]), there is a similar distribution of skeletal relation to the Japanese orthodontic population. Comparing Japanese and Taiwanese to Pakistani, Turkish, and Nepalese, a significantly higher rate of skeletal Class III patients was noted in orients. This result corresponds with a previous study that concluded that most Asians have a brachycephalic head form, a greater tendency toward Class III malocclusion, and a retrognathic midface or prognathic mandibular profile.[27] Comparing the distribution of Angle's

Table 6. Correlation between Skeletal relation to Angle classification.

	Total	p	Male	p	Female	p
	Skeletal		Skeletal		Skeletal	
Angle	0.43	<0.01	0.46	<0.01	0.42	<0.01

Spearman's rank correlation coefficient was conducted.
0 to 0.20: interpreted as no correlation; 0.21–0.40: low correlation.
0.41–0.60: moderate correlation.
0.61–0.80: marked correlation.
0.81–1.00: high correlation.

Table 4. The distribution of skeletal relation between sex.

	Class I	Class II	Class III	p	Class I vs Class II	p	Class II vs Class III	p	Class I vs Class III	p
	N = 1123	N = 728	N = 620		OR (95% CI)		OR (95% CI)		OR (95% CI)	
M	345	215	269	<0.01	1.00	0.587	1.00	<0.01	1.00	<0.01
F	778	513	351		1.06 (0.86–1.30)		0.95 (0.77–1.16)		0.58 (0.47–0.71)	

The Chi-squared test and Multinomial logistic regression were used for analysis.
p-value <0.05 has significant difference.

Table 5. The distribution of Angle's classification between sex.

	Class I	Class II	Class III	p	Class I vs Class II	p	Class II vs Class III	p	Class I vs Class III	p
	N = 970	N = 762	N = 739		OR (95% CI)		OR (95% CI)		OR (95% CI)	
M	287	219	323	<0.01	1.00	0.700	1.00	<0.01	1.00	<0.01
F	683	543	416		1.04 (0.85–1.28)		0.52 (0.42–0.64)		0.54 (0.44–0.66)	

The Chi-squared test and Multinomial logistic regression were used for analysis.
p-value <0.05 has significant difference.

Table 7. Annual distribution of skeletal relation and Angle's classification.

	2016	2017	2018	2019	2020	2021	Mean
Skeletal relation							
Class I	46.1% (219)	40.5% (196)	44.0% (157)	51.4% (192)	42.8% (191)	40.2% (135)	187
Class II	32.3% (153)	34.8% (168)	29.2% (104)	25.4% (95)	27.4% (123)	36.8% (124)	121
Class III	21.7% (103)	24.7% (120)	26.8% (95)	23.2% (86)	29.8% (133)	23.0% (77)	103
Angle's classification							
Class I	41.6% (198)	41.0% (198)	38.8% (138)	37.8% (141)	37.2% (167)	44.2% (148)	162
Class II	31.8% (151)	27.9% (135)	31.0% (110)	32.3% (120)	31.4% (140)	28.8% (97)	127
Class III	26.6% (126)	28.2% (151)	30.2% (108)	29.9% (112)	31.4% (140)	27.0% (91)	123
Total	475	484	356	373	447	336	412

(Data of year 2021 was limited from Jan. 1 to June 30).

classification to other Asian studies, we observed a higher rate of Class II and Class III relations than in study of Shen et al.[14] The was based on a population of schoolchildren in China instead of a single hospital-based population. The sample also comprised multi-ethnicity and different time points. The criterion of malocclusion also contributed to the difference between studies. Angle's normal occlusion was included in study of Shen et al., which was conducted to lower prevalence in all categories of malocclusion. In our study, however, those with Angle's normal occlusion were excluded due to a lack of normal occlusion patients seeking orthodontic treatment. In Yang's Korean study, a significant increase in Angle's Class III malocclusion (49.14%) was noted.[7] Jung's study also revealed 24% of Angle's Class III malocclusion. Compared to Shen et al., both hospital-based studies showed a high prevalence of Class III malocclusion, which may result from sampling bias.[16]

Compared to Caucasian, Hispanic, and Arabs studies, there was a significantly lower percentage of Angle's Class II malocclusion and a higher percentage of Angle's Class III malocclusion. These differences may originate from ethnic factors that cause Caucasians to have the most prevalent Class II malocclusion. African Americans showed the highest prevalence of Class I malocclusions, and Asians had the most prevalent Class III malocclusions.[24]

Compare our study to other hospital-based studies including Yang,[7] Jung,[16] Gul-e-Erum and Fida,[17] Shrestha and Shrestha,[20] Celikoglu et al.,[21] Mohammad et al.,[12] Willems et al.,[6] Grando et al.,[23] and Vig et al.,[25] a noticeable difference in dental relation had shown between Mongoloid and Caucasoid. Yang's[7] and Jung's[16] study both have a higher ratio of Class III molar occlusion than others,[6,20,25] which are lower than 10%. Compared to our sample, which was mainly composed of the Taiwanese population, the Class III molar relation was 29.9%, coinciding with previous orient studies.

Comparing the distribution and correlation of our sample

Compare the prevalence of skeletal relations between males and females. A statistically significant difference in the prevalence of Skeletal Class III between males and females was noted. A statistically significant difference in the prevalence of Angle's Class III between males and females was also noted. A higher prevalence of skeletal Class III and Angle's Class III in the male sample was noted. The Turkish hospital-based study of Celikogu et al. revealed a much lower prevalence of Class III occlusion without an inter-gender difference.[21] Study of Halwai et al. showed a significant difference between sex and skeletal classification.[18]

A correlation of skeletal relation and dental relation was conducted, and the result revealed a moderate correlation between skeletal and dental relation in male, female, and total samples. Compare our results to previous studies conducted by Al-Hamlan et al.,[28] Shrikant et al.,[29] and Zhou et al.,[30] who use ANB angle and Wits appraisal as skeletal criteria and Angle's classification as dental criteria. Al-Halman et al. revealed no significant correlation between Angle's classification and ANB angle.[28] In study of Shrikant et al., however, indicates a significant positive correlation between ANB angle and dental relation.[29] A sample from the general population showed that Wits appraisal is a more accurate reflection of the dental arch relationship than the ANB measurement in study of Zhou et al.[30] The outcome of studies varies, which could owe to different sample populations and statistical methods.

Study limitation

Our study collected data from patients who underwent orthodontic analysis at a medical center. The sample itself could have been biased because

Table 8. Previous studies about the prevalence and distribution of malocclusion.

Author	Country	Year	Sample size	Dentition	Study type	Skeletal Class I (%)	Skeletal Class II (%)	Skeletal Class III (%)	Angle's Class I (%)	Angle's Class II (%)	Angle's Class III (%)
Shen et al.[14]	China	1988~2017	51,100	Mixed, Permanent	Meta analyses				26.5	7.97	12.6
Ota et al.[15]	Japan	2018	1020	Permanent	Hospital based	39.9	33.52	26.57			
Yang[7]	Korea	1990	3305		Hospital based				35.9	14.94	49.14
Jung[16]	Korea	2009	1620	Mixed, Permanent	Hospital based				38.9	37.1	24.0
Gul-e-Erum & Fida[17]	Pakistan	2002~2004	156	Mixed, Permanent	Hospital based	48.7	48.1	5	18.6	70.5	10.9
Halwai et al.[18]	Nepal		200	Mixed, Permanent	Hospital based	43.5	48.5	8			
Zia et al.[19]	Turkey		155	Mixed, Permanent	Hospital based	56	32	12			
Shrestha & Shrestha[20]	Nepal	2008~2013	464	Permanent	Hospital based				54.7	36.9	8.4
Celikoglu et al.[21]	Turkey	2005~2008	1507	Permanent	Hospital based				41.5	38.3	16.7
Mohammad et al.[12]	Iraq	2018~2019	87	Mixed, Permanent	Hospital based				49.4	36.8	13.8
Akbari et al.[22]	Iran	2015	28,693	Mixed, permanent	Meta analyses				54.6	24.7	6.01
Willems et al.[6]	Belgian	1983~1997	1477	Mixed, permanent	Hospital based				31	63	6
Grando et al.[23]	Brazil		926	Mixed, permanent	School based				55.4	21.7	11.3
Vig et al.[25]	USA	1990	438		Hospital based				43.7	50.8	5.5
Alhammadi et al.[24]	Worldwide	1951~2016		Mix	Meta analyses				72.74	23.11	3.98
				permanent					74.7	19.56	5.93
Lombardoet al.[26]	Worldwide	2009~2019		Primary	Meta analyses				54.2	35.3	10.5
				Mixed					60.7	32.6	6.7
				Permanent					61	27.2	11.8
Tsai et al. (current study)	Taiwan	2016~2021	2471	Mixed, permanent	Hospital based	45.4	29.5	25.1	39.3	30.8	29.9

patients seeking orthodontic treatment tend to present high percentage of Class II and Class III malocclusions than the general population.[31] Further, more challenging cases tend to seek treatment in medical centers owing to the need for surgical intervention. Urban/rural differences could also play an important role. Residents of alpine areas tended to have a higher ratio of native Taiwanese residents, and residents of plain areas were diverse. Hoklo Taiwanese and Hakka Taiwanese occupy the central portion of the plain area. However, the genetic influence of different races has yet to be studied. The uneven gender ratio is also present in our study. The ratio of males to females in our sample was approximately 1:2, which deviated from the actual ratio of Taiwanese society, which was 98.2:100 for males to females in 2021.[32] The possible reason for the sampling bias could be attributed to more emphasis on the personal figure in females.

Our sample was consisted of both mix dentition and permanent dentition, which holds 192 (7.78%) and 2279 (92.22%) respectively. Since our study was a cross-sectional retrospective study, our result only represents the situation on the moment of orthodontic data collection. However, present studies have revealed that there was probability of molar relationship change in the late mix dentition during active growth periods and even in the post-pubertal phase of development.[33] Sagittal growth differences between the maxilla and the mandible can be the most significant factor in this correction.[34] Both Baume[35] and Kim et al.[33] described sagittal growth difference of jaws in combination with molar mesial shift in mix dentition could contribute to mesial molar relationship change in most cases. The amount of mesial molar shift ranged from 0.35 mm to 2.28 mm depending on the difference of jaw growth.[33] Nanda and Chawla[36] suggested the amount of mesial shift was depended on leeway space. However, growth difference only affect little after permanent dentition was established.[37] The pubertal growth of maxilla and mandible affects the final setting of molar relation and may cause bias indeed. However, in present study, the transition of molar relationship was yet to be measured. Our statistics only count the molar relationship when receiving orthodontic data collection due to cross-sectional study design.

Besides factors mentioned above, such as treatment difficulty, urban/rural differences, ethnicity bias, and gender bias, methods to classify the samples could also limit the homogeneity of previous comparable studies. The definition of skeletal classification may vary from study to study. In study of Gul-e-Erum & Fida and Zia et al.,[17,19] the definitions of skeletal Class

I, II, and III were set as 0−4°, >4°, <0°, sequentially. In study of Ota et al.,[15] the ANB angle for skeletal Class I was 1.5−5.1° for females and 0.8−4.8° for males, skeletal Class II was >5.1° for females and >4.8° for males, and skeletal Class III was <1.5° for females and <0.8° for males. Studies mentioned above have different criteria compared to our study. The heterogeneity of normal values makes it difficult to compare. When comparing our results with those of previous studies, high heterogeneity may lead to bias. Different sample populations, classification methods, and analysis parameters are the factors that influence the consequence.

The trend of patients visiting KMUH for orthodontic evaluation

In the last five years, we have observed a decreasing rate of skeletal Class I patients and an increasing rate of skeletal Class II patients. In contrast, skeletal Class III patients showed no apparent changes. This trend indicates an increasing number of skeletal Class II patients attending orthodontic evaluation, even during the COVID-19 pandemic. In the trend of Angle's classification, Class II and Class III slightly decreased, and Class I increased. Discuss the number of patients visiting; there was no significant decrease in patients having an orthodontic evaluation, which may imply that the outbreak of COVID-19 did not collapse patients' willingness to have orthodontic treatment in the medical center.

CONCLUSION

In this hospital-based study, the distribution of skeletal relationships and dental classifications may reflect the construction of orthodontic patients in Taiwan's medical centers. In our study, skeletal Class I jaw relation was the most prevalent type of jaw relation. Angle's Class I molar relation is the mostly seen dental relation. However, in the biased nature of our sample, the data of this orthodontic population cannot reflect the entire population of Taiwan. The result also showed a statistically significant higher ratio of skeletal Class III and Angle's Class III malocclusion in male patients than in female patients in our sample. Moderated correlation of skeletal relation and dental classification were also noted.

A larger number sample of the overall population may be acquired without sampling bias. Conversely, the bias of our sample may contribute to elite medical education and orthodontic specialist training programs. Various cases such as orthodontic-surgical combined cases, obstructive sleeping disorder, dentofacial deformity, cleft lip and palate, and complicated orthodontic requirements can seek appropriate treatments in medical centers.

Further studies can emphasize occlusal relations and different etiologic factors, correlations of factors that affect skeletal and dental classification, and observation of upcoming trends in skeletal and dental classification. We also look forward to comparing our results with samples from other medical centers and the entire Taiwanese population to have a more profound analysis.

FUNDING

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ETHICAL APPROVAL

This study was approved by the Institutional Review Board of Kaohsiung Medical University Hospital (No. KMUHIRB-E (II)-20220,150).

CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

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