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ORIGINAL ARTICLE

Differences in third molar development and angulation in class II subdivision malocclusions

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Abstract

Purpose To assess and compare the developmental stages and angulations of third molars between the class II and class I sides in class II subdivision malocclusions.

Methods This retrospective study was performed using panoramic x-rays of 38 individuals (mean age: 15.5 years; 24 females, 14 males) with class II subdivision malocclusions, which were further divided into type 1 and 2 subgroups according to midline deviation, and a control group of 42 individuals (mean age: 17.0 years; 30 females, 12 males) with normal occlusion. Third molars were categorized using the developmental stages defined by the Demirjian method. Angles between the third molars and horizontal reference lines and also to the second molars were measured.

Results No difference was found in developmental stages or angulations between the left and right third molars in the control group. In the class II subdivision malocclusion cases, no difference in third molar developmental stages was observed, but the angle between the long axes of the mandibular third and second molars was significantly greater on the class II side. In the type 2 subgroup, developmental stage of the maxillary third molar was more advanced on the class II side. In both subgroups, the angles of the maxillary third molars' long axis to the interorbital plane differed significantly between the two sides.

Conclusion Class II subdivision malocclusion may cause differences in third molar development and angulations between the two sides. Orthodontic treatment should be planned considering the third molars in this malocclusion.

Keywords Unilateral class II molar relationship · Developmental stage · Demirjian method · Malocclusion, -Angle class II · Tooth eruption

Unterschiede in der Entwicklung und Angulation der dritten Molaren bei Klasse-II-Subdivisionsfehlstellungen

Zusammenfassung

Zielsetzung Beurteilung und Vergleich der Entwicklungsstadien und Angulationen der dritten Molaren zwischen der Klasse-II- und Klasse-I-Seite bei Subdivisionsfehlstellungen der Klasse II.

Availability of data and material The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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Methoden Diese retrospektive Studie wurde anhand der Panoramaröntgenbilder von 38 Personen (Durchschnittsalter: 15,5 Jahre; 24 Frauen, 14 Männer) mit Klasse-II-Subdivisionsfehlstellungen durchgeführt, die je nach Mittellinienabweichung in Untergruppen vom Typ 1 und 2 eingeteilt wurden, sowie einer Kontrollgruppe von 42 Personen (Durchschnittsalter: 17,0 Jahre; 30 Frauen, 12 Männer) mit normaler Okklusion. Die dritten Molaren wurden anhand der Entwicklungsstadien nach der Demirjian-Methode kategorisiert. Die Winkel zwischen den dritten Molaren und den horizontalen Referenzlinien sowie zu den zweiten Molaren wurden gemessen.

Ergebnisse In der Kontrollgruppe wurde kein Unterschied hinsichtlich der Entwicklungsstadien oder Achsstellung zwischen den linken und rechten dritten Molaren festgestellt. In der Untergruppe der Klasse-II-Fehlstellungen wurde kein Unterschied hinsichtlich der Entwicklungsstadien der dritten Molaren festgestellt, aber der Winkel zwischen den Längsachsen der dritten und zweiten Molaren des Unterkiefers war auf der Seite der Klasse II signifikant größer. In der Untergruppe Typ 2 war das Entwicklungsstadium des dritten Molaren im Oberkiefer auf der Klasse-II-Seite weiter fortgeschritten. In beiden Untergruppen unterschieden sich die Winkel der Längsachse der oberen dritten Molaren zur Interorbitalebene signifikant zwischen den beiden Seiten.

Schlussfolgerung Eine Klasse-II-Subdivisionsfehlstellung kann Unterschiede in der Entwicklung und der Achsstellung der dritten Molaren zwischen den beiden Seiten verursachen. Die kieferorthopädische Behandlung sollte bei dieser Malokklusion unter Berücksichtigung der dritten Molaren geplant werden.

Schlüsselwörter Einseitige Klasse-II-Molarenbeziehung · Entwicklungsstand · Demirjian-Verfahren · Angle-Klasse-II-Malokklusion · Zahndurchbruch

Abbreviations
ICC Intraclass correlation coefficient

Introduction

Class II subdivision has been defined as a particular group of class II malocclusions described by unilateral class II molar relationship [1]. The literature indicates that the primary factor conducive to the asymmetric sagittal relationship in class II subdivision malocclusions is the dentoalveolar component [2, 3].

Class II subdivision malocclusion may be categorized into two types: In type 1 the lower first molar is positioned more distally on the class II side, and in type 2 the upper first molar is positioned more mesial on the class II side. Typically, the lower midline deviates towards the class II side in type 1, while in type 2 the upper midline deviates towards the opposite side [3, 4].

The main factor of the asymmetry must be determined before orthodontic treatment planning to correct subdivision problems [2]. Janson et al. [5] investigated third molar angulation and the retromolar eruption space in this asymmetric malocclusion and observed a difference in mandibular third molars angulation and third molars space availability between the two sides of class II subdivision malocclusion cases. Long-term studies have shown that several conditions are associated with third molar impaction, including lack of eruption space in the retromolar region [6, 7], third molar angulation [8, 9], early or late third molar mineralization [10, 11], and other factors including sex, socioeconomic differences, as well as genetic and endocrine factors [12].

There is a lack of conclusive literature evidence on the association between the formation and angulation of third molars in class II subdivision malocclusion. The aims of the present study were to assess the developmental stages and angulations of the third molars between the class II and class I sides in class II subdivision malocclusions and its subgroups. The null hypothesis was that third molars show no difference for developmental stage or angulation in class II subdivision malocclusions.

Materials and methods

This retrospective study was approved by the Ethics Committee of Bezmialem Vakif University (approval no.: 04/57). Individuals were collected from the records of the archives of the orthodontics department of Bezmialem Vakif University Faculty of Dentistry.

The study group consisted of 38 individuals (mean age: 15.48 ± 2.61 years; 24 females, 14 males) with Angle class II subdivision malocclusions. The primary selection criteria for patients in the study group were at least half cusp class II molar relationship on one side and a class I molar relationship on the other side. The control group consisted of 42 individuals (mean age: 17.00 ± 3.38 years; 30 females, 12 males) with Angle class I molar and canine relationships with minor or no crowding and no midline discrepancy.

Other selection criteria for both groups were as follows: (1) presence of all teeth including the third molars; (2) no severe crowding; (3) no anterior or posterior crossbite; (4) no lateral functional shift on the mandible; (5) no

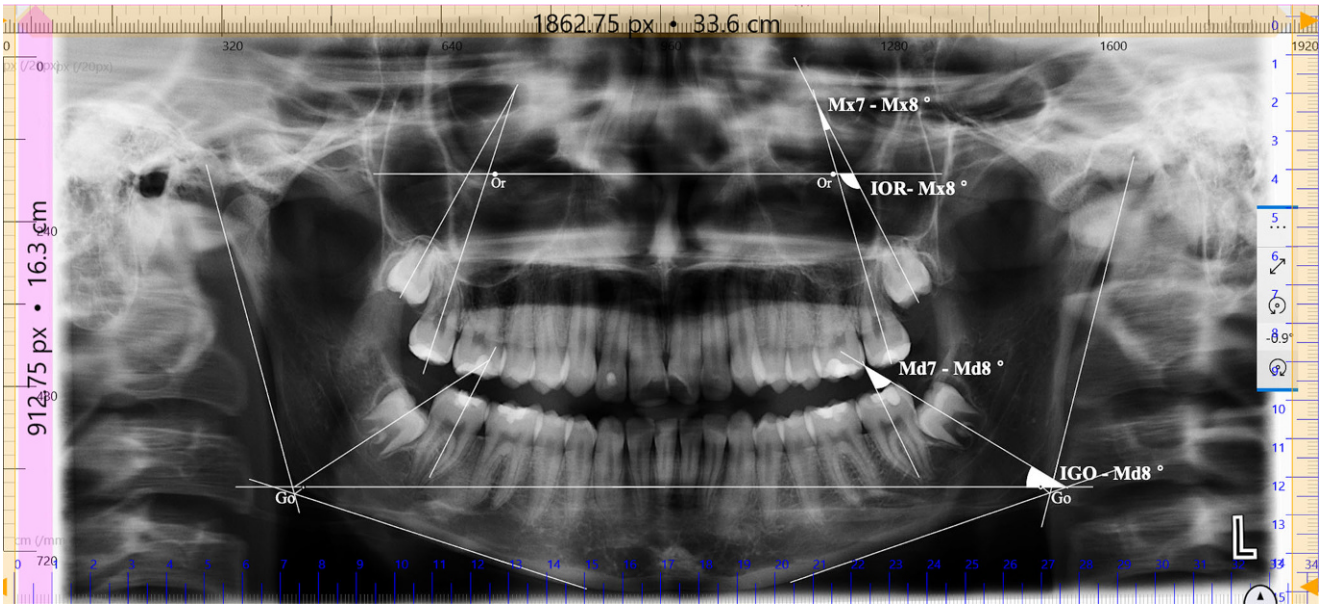

Fig. 1 Angular measurements used in the study. *IOR-Mx8* angulation of the maxillary third molar long axis to interorbital line, *Mx7-Mx8* angle between the long axes of maxillary second and third molars, *IGO-Md8* angulation of the mandibular third molar long axis to intergonial line, *Md7-Md8* angle between the long axes of mandibular second and third molars

Abb. 1 In der Studie verwendete Winkelmessungen. *IOR-Mx8* Winkel der Längsachse des oberen dritten Molaren zur Interorbitallinie, *Mx7-Mx8* Winkel zwischen den Längsachsen der oberen zweiten und dritten Molaren, *IGO-Md8* Winkel der Längsachse des unteren dritten Molaren zur Intergoniallinie, *Md7-Md8* Winkel zwischen den Längsachsen der unteren zweiten und dritten Molaren

history of previous orthodontic treatment; and (6) no craniofacial syndrome. These criteria were evaluated from diagnostic records including clinical charts, dental casts, photographs and panoramic radiographs. All panoramic x-rays used in this study were obtained under standard conditions using the same equipment (ProMax, Planmeca, Helsinki, Finland).

The class II subdivision malocclusion group was divided into subgroups due to midline deviation. In the type 1 subgroup, the upper midline was coincident to the facial midline, while the lower midline shifted towards the class II side. In the type 2 subgroup, on the contrary, the lower midline was coincident to the facial midline and the upper midline shifted towards the class I side. The type 1 subgroup had 20 individuals (6 males, 14 females), and the type 2 subgroup had 14 individuals (6 males, 8 females). The other 4 patients were not included in the subgroup assessment because they exhibited mixed characteristics of types 1 and 2.

Classification of third molar developmental stages and angular measurements were performed on panoramic radiograph by a single investigator (S. A.). Third molars were categorized using the developmental stages defined by Demirjian et al. [13], which include eight stages of calcification (A–H).

Panoramic landmark identification and measurements were performed digitally using Microsoft Measura X software (Microsoft, Redmond, WA, USA). Angular measurements were made as the mesial angles between the long axes of the third molars and horizontal reference lines (see below) and between the long axes of the third and second molars. In order to accurately determine the long axes of the third molars, measurements were made from teeth at stage E or later, in which calcification of the radicular bifurcation has started. Therefore, angular measurements were performed using the panoramic x-rays of 21 individuals in the class II subdivision malocclusion group, 10 individuals in the type 1 subgroup, 8 individuals in the type 2 subgroup, and 34 controls.

Measurements used in the study were made as follows:

- Tangential lines were drawn along the posterior and inferior borders of the mandible. The point where the bisector of the angle between these two lines first touched the mandible was identified as gonion. The line passing through the right and left gonion was considered the horizontal reference line for the mandible [14].
- The horizontal reference line for the maxilla was obtained by joining the right and left orbitale (the most inferior point of the orbital cavity) [15].
- The longitudinal axes of the third and second molars were drawn through the midpoint of the occlusal surface and the radicular bifurcation.

The reference planes and angular measurements are illustrated in Fig. 1.

Statistical analysis

Statistical analysis was performed with SPSS Statistics (version 22.0; IBM Corp., Armonk, NY, USA). A p-value <0.05 was considered to be statistically significant.

To determine the level of error in determining formation stages and angulations, 20 panoramic radiographs were randomly selected from both groups and the measurements and classifications were repeated by the same examiner after a 2-week interval. The intraclass correlation coefficient (ICC) was calculated for the analysis of intraobserver reliability.

Shapiro–Wilk test was used to test the variables for normal distribution. The third molar developmental stages and angulations of the two sides in both groups and subgroups were compared with the paired-samples t test if the variables were normally distributed and with the Wilcoxon test if the variables were not normally distributed. Mann–Whitney U tests were used to analyze third molar angular asymmetries between the study and the control group.

Results

The ICC values ranged between 0.89 and 0.98 for the developmental stage and between 0.92 and 0.99 for all angular measurements. No variables showed statistically significant systematic error.

Means and standard deviations were calculated for each variable. No significant difference was found for the third molar formation stages between the two sides in the class II subdivision group or the control group (Table 1).

All angulations of third molars were similar in both sides of the control group. In the class II subdivision group, the angle between the mandibular third and second molar long axes was significantly greater on the class II side (Table 2). There was a similar angular asymmetry between the class II subdivision malocclusion and the control group (Table 3).

No difference was observed for the third molar developmental stage between the two sides in the type 1 subgroup of class II subdivision malocclusion, while the type 2 subgroup of class II subdivision malocclusion showed a significant difference in the developmental stages of the maxillary third molars between the two sides (Table 4). In the type 1 subgroup, the angle between the interorbital plane and the upper third molars were statistically greater on the class II side, while this angle was greater on the class I side in the type 2 subgroup (Table 5).

Table 1 Comparison of the third molars formation stages with the Wilcoxon test between the class I and class II sides of the class II subdivision group and between the right and left sides of the control group

Tab. 1 Vergleich der Entwicklungsstadien der dritten Molaren mit dem Wilcoxon-Test zwischen den Klasse-I- und den Klasse-II-Seiten der Klasse-II-Subdivisionsgruppe sowie zwischen den rechten und linken Seiten der Kontrollgruppe

Class II subdivision group ($n=38$)						Control group ($n=42$)				
	Class I side		Class II side			Right side		Left side		
	Mean	SD	Mean	SD	P value	Mean	SD	Mean	SD	P value
Mx8 formation	5.00	1.90	5.08	1.84	0.36	5.64	1.79	5.67	1.72	0.78
Md8 formation	4.97	1.73	4.87	1.76	0.10	5.57	1.76	5.55	1.81	0.7

SD Standard deviation, *Mx8* Maxillary third molar, *Md8* Mandibular third molar

Table 2 Comparison of the third molar angular measurements with the Wilcoxon test between the class I and class II sides of the class II subdivision group and between the two sides of the control group

Tab. 2 Vergleich der Entwicklungsstadien der dritten Molaren mit dem Wilcoxon-Test zwischen den Klasse-I- und den Klasse-II-Seiten der Klasse-II-Subdivisionsgruppe sowie zwischen den beiden Seiten der Kontrollgruppe

Class II subdivision group ($n=21$)						Control group ($n=34$)				
	Class I side		Class II side			Right side		Left side		
	Mean	SD	Mean	SD	P value	Mean	SD	Mean	SD	P value
IOR-Mx8 (°)	111.33	15.51	112.43	11.66	0.61	115.15	12.04	115.71	14.21	0.85
Mx7-Mx8 (°)	11.71	7.95	10.29	6.82	0.57	10.62	6.03	10.76	8.71	0.90
IGO-Md8 (°)	48.67	14.18	46.71	31.86	0.31	48.38	15.04	46.71	14.20	0.46
Md7-Md8 (°)	19.43	11.09	30.33	21.17	**0.03***	19.18	12.47	20.59	12.61	0.50

SD standard deviation, *IOR* interorbital line, *IGO* intergonial line, *Mx8* Maxillary third molar, *Mx7* Maxillary second molar, *Md8* Mandibular third molar, *Md7* Mandibular second molar

*Statistically significant at $P<0.05$

Table 3 Results of Mann–Whitney U test between third molar angular asymmetries of the class II subdivision malocclusion and control groups
Tab. 3 Ergebnisse des Mann-Whitney-U-Tests zwischen den Winkelasymmetrien der dritten Molaren bei Klasse-II-Subdivisionsfehlstellung und in der Kontrollgruppe

	Class II subdivision group ($n=21$)		Control group ($n=34$)		
	Mean	SD	Mean	SD	P value
Age	17.10	2.16	17.59	3.12	0.79
IOR-Mx8 asym (°)	10.81	8.42	7.50	6.68	0.12
Mx7-Mx8 asym (°)	8.10	5.40	6.26	6.70	0.09
IGO-Md8 asym (°)	14.62	22.22	8.50	7.50	0.83
Md7-Md8 asym (°)	13.76	20.30	6.29	6.63	0.38

SD standard deviation, *IOR* interorbital line, *IGO* intergonial line, *Mx8* Maxillary third molar, *Mx7* Maxillary second molar, *Md8* Mandibular third molar, *Md7* Mandibular second molar, *asym* Asymmetry

Table 4 Comparison of the third molar formation stages between the two sides of the type 1 subgroup of class II subdivision malocclusion with the paired t test and the type 2 subgroup of class II subdivision malocclusion with the Wilcoxon test
Tab. 4 Vergleich der Entwicklungsstadien der dritten Molaren zwischen den beiden Seiten der Klasse-II/1-Subdivisionsgrupe mit dem gepaarten t-Test und der Klasse-II/2-Subdivisionsgrupe mit dem Wilcoxon-Test

Class II subdivision type 1 subgroup ($n=20$)						Class II subdivision type 2 subgroup ($n=14$)				
	Class I side		Class II side			Class I side		Class II side		
	Mean	SD	Mean	SD	*P* value	Mean	SD	Mean	SD	*P* value
Mx8-formation	4.80	1.99	4.80	1.94	1	5.07	1.90	5.36	1.74	**0.04***
Md8-formation	4.90	1.77	4.70	1.87	0.42	4.93	1.77	4.93	1.69	1

SD Standard deviation, *Mx8* Maxillary third molar, *Md8* Mandibular third molar
*Statistically significant at $P<0.05$

Table 5 Comparison of third molar angular measurements between the class I and class II sides of the type 1 and type 2 subgroups with the paired t test
Tab. 5 Vergleich der Winkelmessungen der dritten Molaren zwischen den Seiten der Klasse-I- und der Klasse-II-Subdivisionsgruppen vom Typ 1 und Typ 2 mit dem gepaarten t-Test

Class II subdivision type 1 subgroup ($n=10$)						Class II subdivision type 2 subgroup ($n=8$)				
	Class I side		Class II side			Class I side		Class II side		
	Mean	SD	Mean	SD	*P* value	Mean	SD	Mean	SD	*P* value
IOR-Mx8 (°)	105.90	13.03	114.20	10.33	**0.03***	121.50	14.47	111.12	15.11	**0.04***
Mx7-Mx8 (°)	11.60	7.23	10.10	5.61	0.94	13.87	8.44	12.00	8.67	0.22
IGO-Md8 (°)	50.60	15.85	55.60	43.58	0.57	50.00	13.61	39.87	15.20	0.68
Md7-Md8 (°)	18.10	10.73	29.10	25.46	0.26	18.75	12.99	31.87	20.82	0.13

SD standard deviation, *IOR* interorbital line, *IGO* intergonial line, *Mx8* Maxillary third molar, *Mx7* Maxillary second molar, *Md8* Mandibular third molar, *Md7* Mandibular second molar
*Statistically significant at $P<0.05$

Discussion

Several studies have shown that the dentoalveolar component is the primary factor contributing to the sagittal asymmetry in class II subdivision malocclusions [2, 3]. In the present study, it was aimed to compare the developmental stages and angulations of the third molars between the two sides in class II subdivision malocclusion cases. We also evaluated whether these parameters differ in the subgroups of this malocclusion, which are characterized by mandibular or maxillary asymmetric first molar position.

Several methods have been described for evaluating tooth development [13, 16–19]. There are differences in the number of stages and the definitions of each stage among these methods. The classification presented by Demirjian et al. [13] is defined by changes in shape, not on the basis of speculative estimates of length. Dhanjal et al. [20] investigated the reproducibility of different methods evaluating

the developmental stages of third molars and reported that Demirjian's method presented the best intra- and interexaminer agreement. This method is also one of the most convenient and commonly used methods to determine dental age and tooth developmental stage [21]. Difficulties in determining the exact developmental stage such as teeth being between two consecutive stages or the superimposition of the anatomical structures with the upper third molars can be considered as a limitation of this method [20]. Demirjian's method was preferred in the present study because of its advantages compared to other methods.

Mesiodistal angulations of the third molars were evaluated on panoramic films taken routinely for clinical examination and diagnosis. Linear measurements from panoramic radiographs are less reliable than angular measurements, especially horizontal ones. On the other hand, angular distortions and variability are more frequently found in the premolar and canine region of both arches, whereas the molar areas are comparatively stable [14, 22]. To assess the angulations of third molars, the angles between the second molar long axes and to the interorbital plane for the maxilla and the intergonial plane for the mandible were measured. The bite plate used for panoramic radiography opened the bite and altered the occlusion and may have caused unwanted lateral movements of the mandible. For this reason, independent horizontal reference planes for each jaw were established on the panoramic radiographs. Similarly, Stromotas et al. [23] reported that it is more reliable to measure the angles between reference planes and teeth when using stable reference lines in each jaw separately.

Methods such as drawing a line perpendicular to the midpoint of the mesiodistal width of the crown to define the long axis of third molars in the early stages of development have been used in previous studies [24, 25]. However, determining the long axis of third molars with incomplete root formation was reported to result in a higher rate of measurement errors [26]. In order to minimize these errors, angular measurements were made only from third molars in which the bifurcation had started to calcify (stage E) or at later stages.

No differences were obtained in angulation or developmental stage between the right and left third molars in the control group. While no difference was found in the developmental stages of third molars in individuals with class II subdivision malocclusion, it was observed that the angle between the mandibular third and second molar long axes was significantly greater on the class II side. This can be interpreted as a result of the lower first molar being positioned more distally on the class II side, which adversely affects the mesiodistal angulation of the mandibular third molars [2–4]. Similarly, Janson et al. [5] found that the angulation of the mandibular third molars indicated asymmetry between the sides in class II subdivision patients.

Impaction of mandibular third molars is reported to be more common than in maxillary ones [9]. This can be primarily attributed to the anatomy of the mandible providing a narrow retromolar space between the anterior margin of the ramus and the second molar, which can cause impaction of third molars [28]. Although not sufficient alone to predict impaction, the significantly greater angle between the lower third and second molars on the class II side can be regarded as a factor that increases the possibility of the tooth being impacted on that side. Similarly, Jonson et al. [5] found that mandibular third molars demonstrated more favorable eruption angulation on the class I side.

However, when the angulation asymmetry was compared between the control and class II subdivision malocclusion group, no significant difference was found. This may be due to the high standard deviation in the angular measurements of the lower third molars in patients with class II subdivision malocclusion.

While no difference was found in the formation stages of the third molars in the type 1 subgroup of class II subdivision malocclusion, a difference was observed in the developmental stages for the maxillary third molars in the type 2 subgroup, with those on the class II side showing significantly more advanced development. This difference may be due to the fact that the source of the class II subdivision malocclusion in this subgroup is that the upper first molar is positioned more mesially on the class II side than on the class I side, which might accelerate development of the third molar on the class II side [2–4]. This assumption is supported by Marchiori et al. [29] who reported that the third molar mineralization is delayed when there is not enough space for third molar eruption.

Evaluating the calcification stages of third molars can provide clues about the likelihood of their impaction. Previous studies have shown that calcification is slower in impacted third molars than in those that are not impacted [10, 11]. In light of this information, the findings of the present study can be interpreted as indicating that the maxillary third molars have a greater chance for erupting on the class II side in the type 2 subgroup.

When the angulation of the third molars in the subgroups was compared between both sides, it was observed that the angulation of the maxillary third molar was greater on the class II side in the type 1 subgroup and on the class I side in the type 2 subgroup. This finding may be due to a more mesial position of the upper first molar on the class II side [2–4].

The treatment alternatives for class II subdivision malocclusions include nonextraction treatments with intermaxillary elastics [30], extraoral or intraoral distalization [31, 32], fixed functional appliances [30, 33], symmetric or asymmetric premolar extraction treatment protocols [27, 34], and orthognathic surgery [35]. Some studies have

shown that premolar extraction has a positive effect on third molar angulations, increasing the chance for them to erupt [36, 37]. It was pointed out that asymmetric premolar extraction (3 premolar extractions in type 1, 1 premolar extraction in type 2 subgroup), which can be preferred in the treatment of this malocclusion, may have different effects on the third molars and therefore should be considered during treatment planning [5]. However, it is important to individually evaluate the third molars when deciding whether to select distalization or premolar extraction, especially in the type 2 subgroup. Removal of third molars prior to distalization has been recommended because they tend to impede the distal movement of first and second molars [38]. For all these reasons, the orthodontist should carefully evaluate the positions of the third molars when planning treatment for this malocclusion.

A limitation of the current study is that panoramic radiographs were used to measure mesiodistal angulations of the third molars. Earlier studies have pointed out that panoramic radiographs are a reliable indicator of third molar position [14, 22]. However, alterations of the molar position in the buccolingual direction or rotations around the tooth long axis may affect mesiodistal angulations of the third molars on panoramic radiographs [39]. Therefore, it should be noted that panoramic radiographs provide only a two-dimensional evaluation and there are technical limitations. Another limitation of this study was the small number of individuals in the subgroups. A selection criterion that decreased the numbers of individuals was the presence of all teeth including third molars. In addition, performing angulation measurements only in third molars with evident calcification of the bifurcation was another factor that decreased the number of subjects. Future studies with larger sample sizes are needed to enable generalizations of the findings of this study about this malocclusion.

Conclusion

Based upon the results of current study:

- The null hypothesis was disproved. Significant differences were observed in third molar developmental stages and angulations between the two sides in patients presenting with class II subdivision malocclusions.
- No differences in developmental stage or angulation between the right and left upper and lower third molars were found in patients with normal occlusion.

Author Contribution E.S.A: Design of the study, methodology, visualization, writing—original draft; E.D.S: Formal analysis, writing—review and editing; S.A: Data collection, investigation; G.K: Supervision, writing—review and editing.

Declarations

Conflict of interest E. Sunal Akturk, E.D. Seker, S. Akman and G. Kurt declare that they have no competing interests.

Ethical standards This retrospective investigation was approved by the Ethics Committee of Bezmialem Vakif University (18 February 2020, Approval no.: 04/57). **Consent to participate**: The study was retrospective, so (in accordance with the ethical approval) no written informed consent was obtained. **Consent for publication:** Not applicable.

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