ORIGINAL ARTICLE

Effect of impaction on third molar development and age estimation—A study in a Lebanese population

Effet de l'impaction sur le développement de la troisième molaire et l'estimation de l'âge — Une étude avec un échantillon de la population libanaise

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Summary
Background. — The effect of impaction on third molar development is disputable as the scientific literature is not uniform. In parallel, population-specific studies have been encouraged in dental age estimation. This study aimed to investigate the effect of impaction on third molar formation in a sample of Lebanese individuals.
Materials and methods. — The sample consisted of 518 panoramic radiographs of females ($n = 229$) and males ($n = 289$) between 15 and 23.9 years. Mandibular third molars were classified based on their position as non-impacted and impacted (with horizontal, vertical, mesioangular, and distoangular impaction). Dental development was classified according to Demirjian's 8-level staging system.
Results. — Most teeth presented mesioangular impaction (#38 = 29.7%, #48 = 33%). Developing third molars were predominantly distributed between stages D and G. The mean age of most developmental stages was higher among impacted teeth, meaning that third molar mineralization could be slower in the presence of impaction. In general, the delayed dental development

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did not have statistically significant effects ($P < 0.05$). However, descriptive data pointed out differences between (impacted and non-impacted) mean ages of > 12 months—suggesting a potential clinical significance (despite the lack of a statistical one). Furthermore, differences changed based on sex and side (#38/#48).

Conclusion. — Therefore, dental age estimation from third molars in the selected Lebanese population should preferably be performed in non-impacted third molars whenever available.

Introduction

Dental development is the parameter of choice for dental age estimation of children and adolescents [1—3]. Normally, third molars are the only developing teeth in the age interval between 16 and 21.5 years [4—6]. These teeth present high variability of their position in the dental arch [7,8]. In specific, these are the teeth most often impacted [9]. Impaction against the mandibular ramus or the adjacent second molar is common [10]. Studies have suggested a prevalence rate of 23% of at least one impacted third molar [11,12]. Mandibular third molar impaction is more frequent, especially if the tooth has a mesioangular position [13]. The consequences of impaction include decay and resorption of the second molar [11], and the development of periodontal disease [14] and cysts [15]. The effects of impaction on third molar development have differed between studies with diverse populations [16,17].

The existing methods for dental age estimation of children and adolescents are mainly radiographic [18—20] and the preferred methods to assess third molar impaction [11,12]. Two main techniques for evaluating third molar development are radiographic methods for dental age estimation, the application of staging-scoring systems [21,22], and the measurements of open apices [23]. The first relies primarily on developmental stages as categorical variables [21], while the second is based on continuous data represented by the ratios between the tooth length and the width of open apices [23]. Previous studies with the staging-scoring system and the metric methods have indicated a potential delay of third molar formation expressed as the effect of impaction [17,24]. They have highlighted the importance of considering third molar impaction during dental age estimation procedures [24].

To consider impaction in dental age estimation, however, forensic odontologists must know beforehand if the effects of impaction will be detected with different dental age estimation methods. The Demirjian staging system [21] is one of the most used nowadays and has numerous validation studies with populations worldwide [25—30]. The method is based on a system of eight sequential stages, from A to H, representing the course of tooth formation from initial mineralization of cusp tips to apical closure [21]. Studies have used the categorical approach of staging systems to understand the effects of impaction on third molar development [16,24]. While on the one hand, authors have pointed out a similar development of impacted and non-impacted third molars, others suggest that impaction may have a more relevant effect on third molar formation [24]. The present study is justified by the current differences in the scientific literature and by the fact that dental age estimation studies have been encouraged in diverse populations [17].
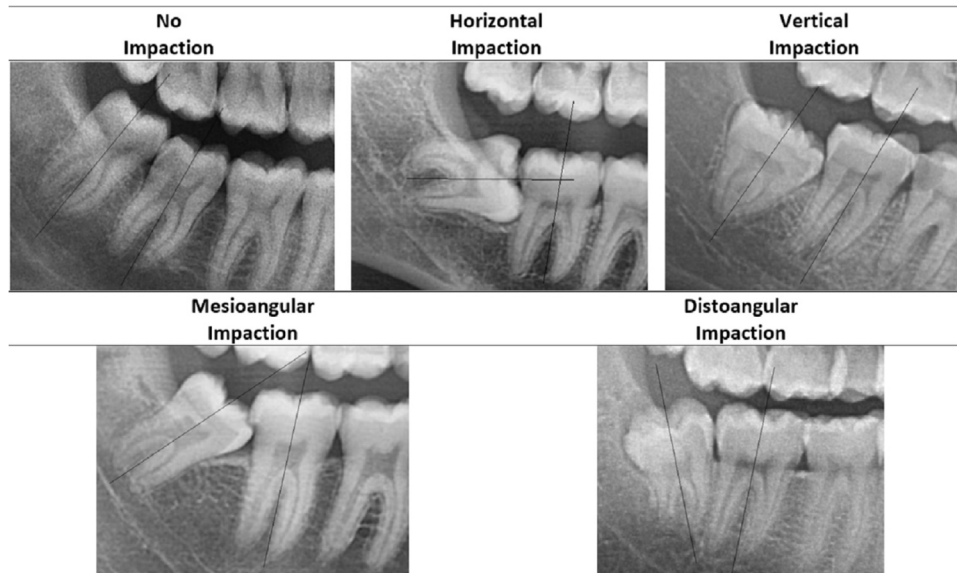
In this context, we aimed to investigate whether third molars have a delayed formation if impacted. The assessment was performed based on a dental staging approach in a Lebanese population.

Table 1 Sample distribution based on sex and age.

Age group	Male	Female	Total
15—15.9	31	26	57
16—16.9	36	33	69
17—17.9	45	31	76
18—18.9	27	18	45
19—19.9	42	29	71
20—20.9	31	19	50
21—21.9	30	30	60
22—22.9	24	22	46
23—23.9	23	21	44
Total	289	229	518

Age expressed in years.

Material and methods

This study was performed according to the ethical standards advocated by the Declaration of Helsinki.

The sample consisted of panoramic radiographs of 518 individuals (229 females and 289 males) between 15 and 23.9 years (median 18 years) (Table 1). The inclusion criteria consisted of radiographs from Lebanese individuals that had a registered date of birth, date of image acquisition, and sex, as well as individuals with all permanent teeth present with at least one-third molar. The exclusion criteria included radiographs with visible bone lesions, signs of systemic disorders, dental and skeletal anomalies, or poor image quality.

Two forensic odontologists with more than eight years of experience in practice, including routine casework of dental age estimation cases of asylum seekers, examined each radiograph. For the left and right third molars, the examiners recorded the status of the teeth as impacted or non-impacted. Impacted teeth were subsequently classified into horizontal, vertical, or angular (mesial or distal) impaction (Fig. 1). Impaction was considered when the tooth was tilted outside the normal path for the eruption in the dental arch. The reference set to assess the type of impaction was the vertical (crown-apex) axis of the permanent mandibular second molar. In this context, the vertical axis of the third molar was compared with the vertical axis of the second

Figure 1 Types of mandibular third molar position and inherent classification of impaction considered in the present study. The impacted third molars were classified based on their position setting as reference the vertical axis of the permanent mandibular second molar.

molar. Impaction could be associated with the mandibular ramus or against the second molar. In parallel, the examiner also recorded the developmental status of the third molars using the staging system of Demirjian et al. [21], 1973. To have each individual's reference (chronological) age, the date of birth was subtracted from the date of image acquisition and converted into decimal values. Later, the chronological age was tested for association with the developmental ages.

The inter-examiner reproducibility test was performed between the classifications of the two main examiners (T1) and between the classifications of the first examiner with a repetition (T2) of his classification performance on 50 randomly selected panoramic radiographs of the sample accomplished one month after the initial analysis.

Statistical analysis was performed using SPSS 22.0 for Windows (IBM Corp, Chicago, IL, USA). The significance level for the analysis was set at 5%. Firstly, Weighted Kappa was used to calculate the intra- and inter-examiner reproducibility to classify third molar developmental status and impaction. Next, Wilcoxon signed-rank test was used to compare the differences in the development of the lower third molars between the left (#38) and right (#48) sides. Descriptive statistics were performed for the developmental stages of third molars and for impacted and non-impacted third molars separately (i.e., mean with standard deviation, minimum age, and maximum age). An Independent t-test was performed to evaluate the difference between impacted and non-impacted third molar groups. Additionally, the probabilities of being over 18 years were calculated for the impacted and non-impacted third molars at stages ''G'' and ''H.''

Results

For the intra-examiner reproducibility, weighted Kappa outcomes were 0.92 and 0.90 for the classification of third molar

Table 2 Type of mandibular third molar impaction distributed per tooth position (left or right).

Impaction type	#38 n (%)	#48 n (%)
Horizontal	41 (8)	31 (6)
Vertical	58 (11.2)	67 (13)
Mesioangular	154 (29.7)	171 (33)
Distoangular	9 (1.7)	5 (1)
Not impacted	256 (49.4)	244 (47)
Total	518 (100)	518 (100)

#38 and #48: left and right mandibular third molars.

mineralization and impaction, respectively. For the inter-examiner reproducibility, the values were 0.89 and 0.91, respectively.

Nearly 50% of the left and right mandibular third molars were impacted. The most common type of impaction was mesioangular impaction ($n = 154$, 29.7% of #38; $n = 171$, 33% of #48) (Table 2).

Third molar stages from B to H were detected in the studied sample. Most of the third molars were between stages D and G, both in males (72.3%) and females (55.8%) (Table 3).

The mean, standard deviation, minimum and maximum age of each third molar (#38 or #48) for every developmental stage, for males and females, is presented in Table 4. In stage G, for instance, the mean age of males is 19.26 ± 1.74 years (minimum = 15.13 years; maximum = 22.49 years) by considering the impacted tooth #38. For males with a non-impacted tooth #38, the mean age is 18.62 ± 1.60 years (minimum = 15.33 years; maximum = 22.47 years) ($P > 0.05$). Statistically significant differences ($P < 0.05$) between impacted and non-impacted third molars were detected only in 2 (16.6%) out of 12 comparisons performed (for each stage and third molar) in males. In these cases, the difference between the mean ages

Table 3 Distribution of third molars per developmental stage of impacted and non-impacted tooth in males and females.

Sex	Stage	#38			#48		
		Impacted	Non-impacted	Total	Impacted	Non-impacted	Total
Male	B	0	0	0	1 (100)	0 (0)	1 (100)
	C	3 (75)	1 (25)	4 (100)	2 (66.7)	1 (33.3)	3 (100)
	D	20 (62.5)	12 (37.5)	32 (100)	20 (69)	9 (31)	29 (100)
	E	16 (50)	16 (50)	32 (100)	23 (67.6)	11 (32.4)	34 (100)
	F	20 (69)	9 (31)	29 (100)	22 (56.4)	17 (43.6)	39 (100)
	G	59 (62.1)	36 (37.9)	95 (100)	52 (61.2)	33 (38.8)	85 (100)
	H	33 (34)	64 (66)	97 (100)	36 (36.7)	62 (63.3)	98 (100)
Female	B	0 (0)	1 (100)	1 (100)	0 (0)	1 (100)	1 (100)
	C	1 (50)	1 (50)	2 (100)	0 (0)	2 (100)	2 (100)
	D	24 (75)	8 (25)	32 (100)	21 (80.8)	5 (19.2)	26 (100)
	E	16 (61.5)	10 (38.5)	26 (100)	20 (62.5)	12 (37.5)	32 (100)
	F	20 (71.4)	8 (28.6)	28 (100)	27 (84.4)	5 (15.6)	32 (100)
	G	30 (51.7)	28 (48.3)	58 (100)	31 (56.4)	24 (43.6)	55 (100)
	H	20 (24.4)	62 (75.6)	82 (100)	19 (23.5)	62 (76.5)	81 (100)

Stages B-H: dental developmental stages proposed by Demirjian et al. (1973). Numbers inside brackets represent the relative frequency (%).

of impacted and non-impacted third molars was below 12 months. In females, all the comparisons showed a lack of statistically significant differences (Table 4).

Discussion

Understanding the potential effects of impaction on third molar development is fundamental to guaranteeing proper dental age estimation in practice. If asylum seekers present impacted third molars, for instance, it would be safe to know if the impaction could delay or not the process of crown-root formation and consequently alter the biological age. Therefore, the test proposed in this study to investigate the effects of impaction on third molar development was designed to assess dental stages individually and the inherent mean, minimum and maximum ages observed in our sample.

It is worth mentioning that dental age estimation studies usually present the mean and standard deviation of the age for the assessed dental developmental stages, but when it comes to third molar development (and age assessment based on the age of majority), experts also should know the minimum age observed per dental stage. Reporting the minimum age is a safety measure to inform the readers of the lower bound of the age interval covered by the dental stage. The upper bound is reported in the present study merely as a matter of complementary descriptive data. The maximum age at stage H observed in this study reflects the maximum age established in the sampling process. In practice, stage H does not have an upper age limit.

When it comes to impaction, most of the stages presented a higher mean age among impacted third molars compared to non-impacted ones. This outcome confirms the rationale for slower mineralization of impacted mandibular third molars. Previous studies observed the same phenomenon [31]. More specifically, authors have observed that individuals with impacted mandibular third molars could be, on average, 0.32—1.88 years older than persons with

non-impacted third molars when they reach the developmental stages F and G—these outcomes were found among Black Africans [31]. The outcomes of our study fall within the age interval reported in the scientific literature. We observed a delayed dental development of almost six months for males in stage G and 1.4 years in stage F when impacted #38 was considered. In females, the delayed mineralization was about one year for both stages. However, the difference between the mean ages of impacted and non-impacted third molars was not statistically significant.

The previous investigation with the South Indian population has found a statistically significant delay in the mineralization of impacted third molars [17], highlighting the importance of population-specific investigations to understand this phenomenon. The current study in the Lebanese population may have demonstrated that the difference between the mineralization timing of impacted and non-impacted third molars may not be so evident from the statistical perspective. On the other hand, because these outcomes may have clinical significance in the process of dental age estimation, it could be prudent to recommend that, whenever feasible, non-impacted third molars should be used for age estimation. This procedure could help tackle the effects of impaction delaying third molar mineralization.

Choosing third molars to assess dental age depends not only on the status of the teeth (impacted or not) but also on the available methods for age estimation. For instance, the I3M method [23] is based originally on tooth #38. Authors have subsequently enabled the assessment of #48 through tests of bilaterality [32]. Gunst et al. [33] reported regressive formulae based on a modified staging system [34] and enabled the calculation of estimated ages for each third molar position, separately or combined, and according to sex. These methods can be applied for dental age estimation when the age of interest is 18 years and when one or more third molars are available. Preferably, non-impacted third molars should be chosen to contribute to a more realistic age assessment. Future studies in the field are encouraged

Table 4 Descriptive outcomes of the chronological age related to the developmental stages of mandibular left and right third molars and their association.

Sex	Stage	Tooth	Impacted				Non-impacted				P
			n	Mean (SD)	Min	Max	n	Mean (SD)	Min	Max	
Male	B	38	-	-	-	-	-	-	-	-	-
		48	1	-	-	-	0	-	-	-	
	C	38	3	15.57 (0.51)	15.16	16.14	1	15.22	-	-	0.608
		48	2	15.43 (0.38)	15.16	15.71	1	15.22	-	-	0.730
	D	38	20	16.27 (1.22)	15.05	19.64	12	16.79 (1.16)	15.02	19.03	0.245
		48	20	16.84 (1.25)	15.13	19.64	9	15.82 (0.73)	15.02	17.37	0.032*
	E	38	16	16.75 (1.77)	15.11	20.73	16	16.60 (1.42)	15.14	20.18	0.790
		48	23	16.73 (1.92)	15.05	20.73	11	16.98 (1.21)	15.54	20.18	0.687
	F	38	20	18.48 (2.34)	15.33	23.43	9	17.09 (1.36)	15.56	19.43	0.110
		48	22	17.98 (2.14)	15.33	23.43	17	16.88 (1.30)	15.13	19.43	0.071
	G	38	59	19.26 (1.74)	15.13	22.49	36	18.62 (1.60)	15.33	22.47	0.077
		48	52	19.43 (1.79)	15.32	23.21	33	18.91 (1.56)	16.18	22.47	0.174
	H	38	33	21.38 (1.83)	17.14	23.38	64	20.71 (2.02)	15.32	23.57	0.112
		48	36	21.53 (1.79)	17.14	23.38	62	20.61 (1.88)	16.97	23.57	0.020*
Female	B	38	-	-	-	-	1	15.49	-	-	-
		48	-	-	-	-	1	15.49	-	-	-
	C	38	1	15.13	-	-	1	15.01	-	-	-
		48	-	-	-	-	2	15.07 (0.08)	15.01	15.13	-
	D	38	24	16.40 (1.85)	15.02	23.23	8	16.20 (1.39)	15.11	19.35	0.789
		48	21	15.88 (1.02)	15.02	19.35	5	15.55 (0.64)	15.11	16.66	0.501
	E	38	16	16.74 (1.52)	15.08	20.23	10	17.41 (1.81)	15.45	21.37	0.327
		48	20	17.33 (1.73)	15.09	21.37	12	17.12 (2.24)	15.08	23.23	0.777
	F	38	20	18.83 (1.96)	16.14	23.19	8	17.81 (2.94)	16.11	23.54	0.292
		48	27	18.67 (2.15)	15.45	23.19	5	17.34 (1.56)	16.11	19.16	0.201
	G	38	30	19.70 (2.06)	15.45	23.41	28	18.72 (1.87)	15.13	22.40	0.064
		48	31	19.70 (1.78)	16.03	22.66	24	19.13 (2.43)	16.25	23.54	0.321
	H	38	20	21.44 (2.14)	15.73	23.40	62	20.76 (1.91)	16.36	23.61	0.185
		48	19	20.78 (2.43)	15.73	23.36	62	20.92 (1.83)	16.48	23.61	0.790

–: stage not registered and descriptive values not quantified.
* Statistically significant differences between the chronological age of impacted and non-impacted third molars. $P < 0.05$ for the significant difference part.

to understand the effects of third molar impaction over the third molar formation in different populations.

Conclusion

Mandibular third molar mineralization is slower in the presence of impaction. However, the differences between impacted and non-impacted third molars seem to be only clinical but not necessarily statistical. Furthermore, in the late phase of root formation, such as stage G, the delay of impacted third molar mineralization could be as high as fourteen months in males and 12 months in females. Therefore, whenever available, non-impacted mandibular third molars should be preferred for age estimation in the Lebanese population.

Disclosure of interest

The authors declare that they have no competing interest.

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