IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 22, Issue 3 Ser.3 (March. 2023), PP 48-56
www.iosrjournals.org

Eruption assessment and potential for impaction of the third mandibular molars - radiographic examination

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Abstract
The aim of this study was to identify risk factors for mandibular third molar impaction and to evaluate the predictability of their eruption using parameters on orthopantomograms.
Panoramic images of 160 patients of both sexes, aged 16-28 years were selected and the position of 220 MM3 were analyzed, before the orthodontic treatment. The subjects were divided into four groups, depending on their degree of impact or eruption: group A (fully erupted and developed MM3), group B (partially erupted, fully developed MM3), group C (unerrupted but completely formatted MM3) and group D (unerupted and partially formated MM3).
Three linear, four angular and two ratios were examined: MM3 width; LES – R (lower eruption space – ramus), LES - Xi (lower eruption space – Xi); α-angle (third molar and the gonio-symphysis plane); β - angle (axes of the lower second and third molars); γ - angle (second molar and the mandibular plane); Go – angle; R1 ratio (LES-R/MDW) and R2 ratio (LES-Xi/MDW).
The conclusions drawn from this study are that the possibility of MM3 eruption depends on several factors and different relationships might have an impact on this process. Tooth inclination (angles α and β) as well as gonial angle, along with space parameters, are measures of great importance for predicting the eruption of the third molar. Retromolar space was significantly higher in the eruptive group. Decreased LES (LES -R and LES - Xi) and decreased space/width ratio, leads to an increased degree of impaction and are a good radiographic predictor for estimation the MM3 impaction.
***Key words**: third molar impaction, orthopantomogram, retromolar space, linear parameters, angular parameters*

Date of Submission: 24-02-2023 Date of Acceptance: 06-03-2023

I. Introduction

Tooth impaction is a pathological condition in which the tooth fails to reach its normal functional position. The etiology of permanent teeth impaction involves several systemic and local factors. The most common local factors include insufficient length of jaw arch, supernumerary teeth, abnormal pathways of eruption, the persistence or untreated odontogenic infections on decioduous teeth, odontogenic tumors and clefts lip and palate. Down's syndrome, Cleidocranial dysplasia, endocrine deficiencies, febrile illnesses and irradiation are some of the systemic factors. The third molars are the teeth that are most often affected by agenesis, but the occurrence of impaction should not be neglected.[1-3] They shows large variations in size, shape, position, root formation, development time and outbreak path. A certain degree of crown formation can last from 7 to 8 years.[4] Gender, racial and socio-economic differences, genetic and endocrinological factors can also influence the eruption process.[5]

The prevalence of impacted third molars ranges from 17–32% of all impacts, almost the same for the upper and lower jaw, significantly higher in women. In a good position, they usually erupt at the age of 17-21, but still 40% of them remain partially or completely anchored in the bone. The reduced eruption space between the second permanent molar and the mandibular ramus has been shown to be one of the most important factors in the etiology of impaction of the third mandibular molar (MM3).[6]

Various skeletal factors have been suggested as significant in variations in retromolar space size: length of mandibular growth and direction of condyle growth, both with direction of tooth eruption.[7-9] Björk et al found that vertically directed condylar growth was the most important factor, as well as reduced alveolar prognathism and delayed tooth maturation.[10] The correlation between growth and length of the mandible and the risk of impaction was examined also.[11-15] Several studies have shown a higher risk of lower third molar impaction in subjects with shorter mandibular length.[10,11,13] Narrow mandible and small mandibular angle were almost always associated with third molar impaction, estimated at 18 years of age.[11]

However, some studies have shown that even in cases with adequate retromolar space, the third molars eruption is disabled, which indicates that there are other factors have an impact on this process.[8,11]

Furthermore, Janson have demonstrated that the available retromolar space can vary between Class II and Class I, indicating that the sagittal skeletal relationships can also affect the fate of these teeth.[16]

Because the results between the researchers were surprisingly controversial,[12-15] the idea was to investigate whether the distances between anthropologic features may be useful in predicting third molar eruption.

It has been noted that excessive initial mesial angulation and minimal straightening during the follow-up process may increase the likelihood of MM3 impaction.[6,7,11,17,18] Minimal vertical correction during movement may increase the likelihood (risk) of disturbed eruption of mandibular third molars.[19]

Erupted third molars are in a slightly more advanced stage of development at a younger age;[5,11] and late mineralization and delayed root development are associated with the high risk of impaction.[20,21]

Unwanted angulations or the aberrant path of eruption, the overlap with dense hard and soft tissues and the late eruption sequence, are also part of the etiological factors for the occurrence of MM3 retention.[3]

Objectives of the research were to determine whether distances between anthropological landmarks can be useful in predicting the impaction or eruption of the third molar and identify pretreatment parameters that could predict impaction, based on radiographic assessment.

II. Material and method

In the research, panoramic images of 160 patients of both sexes, aged 16-28 years were selected and the position of 220 mandibular third molars were analyzed, before the orthodontic treatment.

The subjects were divided into four groups, depending on their degree of impact or eruption:

Group A - fully erupted and developed MM3, which reach the occlusal plane, both clinically and radiographically;

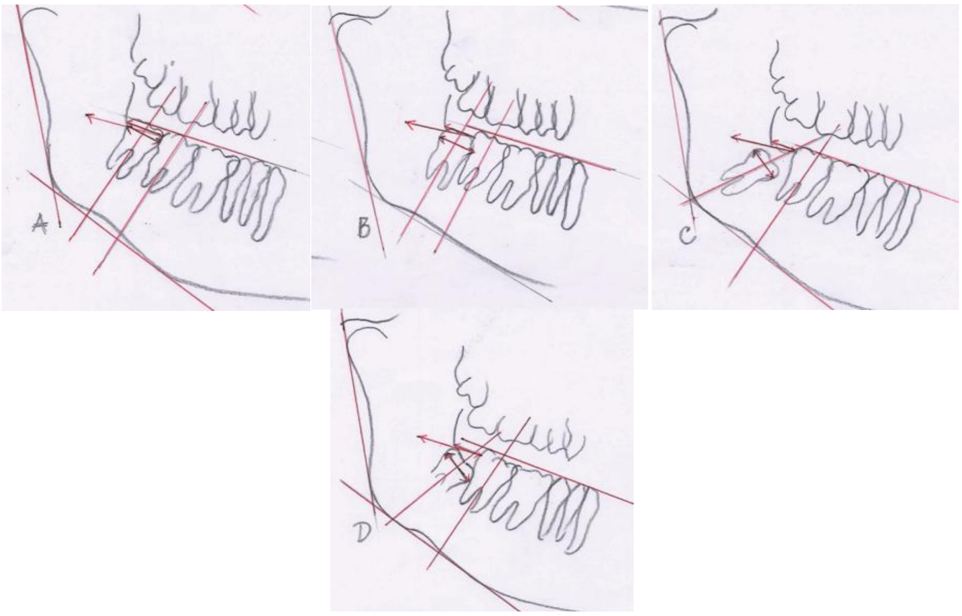
Group B - partially erupted MM3, that are fully developed but do not reach the occlusal plane;

Group C - unerrupted MM3, that are clinically unerrupted, but radiographically show complete root formation;

Group D - unerrupted MM3, partially developed MM3 that are not clinically visible and radiographically do not have a complete root formation.

Nine variables (three linear, four angular and two ratios) were examined on the panoramic images: MDW, mesiodistal width of the third molar at its largest diameter; LES - R: lower eruption space - ramus, space available for eruption of the third molar to the ramus, measured from a drawn line passing through the distal surface of the lower second molar to the anterior edge of the ramus, following the occlusal plane; LES - Xi : lower eruption space - Xi, available eruption space of the third molar to Xi, measured from the line descending from the distal surface of the second molar to Xi point according to Ricketts; α - angle, formed by the axial axis of the lower third molar and the gonio-symphysis plane; β - angle forming the axes of the lower second and third molars, γ - angle formed by the axial axis of the lower second molar and the mandibular plane; Go - angle, located between the plane of the mandible and the plane passing along the distal surface of the ramus; R1, ratio between LES-R and MDW, R2 ratio, between LES-Xi and MDW.

Fig 1. Linear and angular measurements in groups: fully erupted and developed MM3, which reach the occlusal plane (A); partially erupted MM3, that are fully developed but do not reach the occlusal plane (B); clinically unerrupted MM3, but radiographically show complete root formation (C); partially developed MM3 and not clinically visible.



Statistical analysis: The data obtained from the research were analyzed with the statistical program SPSS for windows 23.0. To test the normality in the data distribution was used Shapiro Wilk's test. Quantitative features are shown with arithmetic mean and median, qualitative features are shown with absolute and relative numbers. Bivariate analysis was performed to compare the linear, angular measurements and ratios R1 and R2 between the analyzed groups (Student t-test and Mann-Whitney test). Values of p<0.05 were considered statistically significant.

III. Results

A comparison of group A versus group B in terms of linear measurements showed that these two groups differ significantly for the mesiodistal width of the third molar and it is larger in the group of partially erupted third molars (p=0.005); and in the available space in the arch between the distal surface of the second molar to the ramus (p<0.0001), while the difference in relation to LES–Xi, was statistically unsignificant (p=0.37). Angular measurements presented a statistically significant intergroup difference for α, β and Go - angle (p=0.0007, p=0.0008 and 0.00004 respectively), and a statistically unsignificant difference only for γ - angle (p=0.83). The analyzed ratios R1 (LES-R/MDW) and R2 (LES-Xi/MDW) were significantly higher in the group of fully erupted versus partially erupted third molars (1.04 vs 0.74; p<0.0001 for R1 ratio, and 2.38 vs 2.23 ; p=0.0042, for R2 ratio) (table no.1).

Table no 1. Descriptive statistics for linear and angular measurements and ratios among groups A and B

groups	descriptive statistics		**P value**
	mean ± SD	min - max	
mesiodistal width of the third molar			
A	13.18 ± 1.03	11 – 15	t=2.86
B	13.70 ± 0.9	11 – 15	p=0.005** sig
LES - R (distal surface of third molar to ramus)			
A	13.78 ± 4.0	7 – 25	t=5.82
B	10.12 ± 2.8	3 – 14	p=0.00000*** sig
LES -Xi (distal surface of third molar to Xi point)			
A	31.28 ± 4.3	20 – 42	t=0.89
B	30.60 ± 4.04	22 – 37	p=0.37 ns
R1 ratio (LES-R / MDW)			
A	1.04 ± 0.3	1 (0.92 – 1.14)	Z=5.95
B	0.74 ± 0.2	0.78 (0.6 – 0.92)	p=0.000000*** sig
R2 ratio (LES - Xi / MDW)			
A	2.38 ± 0.3	2.48 (2.22 – 2.58)	Z=2.86
B	2.23 ± 0.2	2.33 (2.08 – 2.43)	p=0.0042** sig
α - angle (angle between axial axis of third molar and Go-Sy plane)			
A	78.58 ± 11.5	15 – 93	t=3.47
B	72.67 ± 13.4	43 – 90	p=0.0007** sig
β - angle (angle between axil axis of third and second molar)			
A	10.10 ± 10.97	8.5 (4.5 – 14)	Z=3.36
B	14.17 ± 8.5	11 (9.5 – 20)	p=0.0008** sig
γ - angle (angle between axial axis of second molar and MPl)			

A	83.80 ± 5.6	68 – 97	t=0.22 p=0.83 ns
B	83.57 ± 6.04	70 – 90	
Go – angle			
A	124.07 ± 7.3	103 – 140	t=4.25 p=0.00004*** sig
B	118.57 ± 6.8	110 – 140	

t (Student t-test) ; Z(Mann-Whitney U Test **p<0.01 sig ***p<0.0001

The mesiodistal width had a similar value in the fully erupted and unerupted, but formatted mandibular third molars groups (13.18 ± 1.03 vs 13.20 ± 1.5; p=0.72). The average values of the LES – R parameter were 13.78 ± 4.0 and 8.0 ± 2.7. The difference of 5.78 was statistically confirmed as significant (p<0.0001). For p=0.00003, the difference of 3.5 in the average value of the LES-Xi parameter between groups (31.28 ± 4.3 vs 27.78 ± 4.6) was confirmed as statistically significant, too. Groups had significantly different values for α-angle (p<0.0001) and β-angle (p<0.0001), while the values of γ- and Go-angle between these two groups were not statistically significant (p=0.86, p=0.064, respectively). In the group with fully erupted molars compared to the group of non-erupted molars, significantly higher R1 and R2 ratios were obtained. The median values of the LES-R/MDW ratio were 1,04 in group A, 0.61 in group C; the median values of the LES-Xi/MDW ratio were 2.38 in group A, 2.12 in group C (table no.2).

Table no 2. Descriptive statistics for linear and angular measurements and ratios among groups A and C

groups	descriptive statistics		**P value**
	mean ± SD	min - max	
mesiodistal width of the third molar			
A	13.18 ± 1.03	11 – 15	t=0.36 p=0.72 ns
C	13.20 ± 1.5	9 – 15	
LES - R (distal surface of third molar to ramus)			
A	13.78 ± 4.0	7 – 25	t=9.27 p=0.00000*** sig
C	8.0 ± 2.7	1 – 14	
LES -Xi (distal surface of third molar to Xi point)			
A	31.28 ± 4.3	20 – 42	t=4.35 p=0.00003*** sig
C	27.78 ± 4.6	16 – 36	
R1 ratio (LES-R / MDW)			
A	1.04 ± 0.3	1 (0.92 – 1.14)	Z=7.75 p=0.000000*** sig
C	0.61 ± 0.2	0.62 (0.47 – 0.77)	
R2 ratio (LES - Xi / MDW)			
A	2.38 ± 0.3	2.48 (2.22 – 2.58)	Z=2.86 p=0.0042** sig
C	2.12 ± 0.3	2.23 (1.92 – 2.33)	
α - angle (angle between axial axis of third molar and Go-Sy plane)			
A	78.58 ± 11.5	15 – 93	t=4.47 p=0.000008*** sig
C	53.63 ± 27.9	4 – 90	
β - angle (angle between axil axis of third and second molar)			
A	10.10 ± 10.97	8.5 (4.5 – 14)	Z=5.4 p=0.000000** sig
C	31.95 ± 23.97	24.5 (14 – 48.5)	
γ - angle (angle between axial axis of second molar and MPl)			
A	83.80 ± 5.6	68 – 97	t=0.18 p=0.86 ns
C	83.97 ± 4.6	71 – 90	
Go – angle			
A	124.07 ± 7.3	103 – 140	t=1.87 p=0.064 ns
C	121.62 ± 7.1	107 – 135	

t (Student t-test) ; Z(Mann-Whitney U Test **p<0.01 sig ***p<0.0001

The mesiodistal width had a similar value in the fully erupted and non-erupted partially developed with non complete root formation mandibular third molar groups (13.18 ± 1.03 vs 13.32 ± 2.1; p=0.65). Groups A and D differed significantly for LES-R and LES-Xi parameters (p<0.0001). The average values of the LES–R parameter in groups were 13.78 ± 4.0 and 7.28 ± 4.4, and for the LES–Xi parameter were 31.28 ± 4.3 and 26.63 ± 4.8, respectively. Angular measurements showed that both groups had significantly different α- and β angles (p<0.0001). The α-angle had a significantly higher average value in the group of fully erupted molars (78.58 ± 11.5 vs 62.53 ± 12.9), while the angle β had a significantly higher value in the partially developed non-erupted molars group (20.47 vs 10.10). Groups had similar, unsignificantly different values for the γ angle (p=0.34) and the Go angle (p=0.36). A statistically significant difference was confirmed between the groups for the LES-R/MDW and LES-Xi/MDW (p<0.0001) (table no.3).

Table no 3. Descriptive statistics for linear and angular measurements and ratios among groups A and D

groups	descriptive statistics		**P value**
	mean ± SD	min - max	
mesiodistal width of the third molar			
A	13.18 ± 1.03	11 – 15	t=0.45 p=0.65 ns
D	13.32 ± 2.1	1 – 15	
LES - R (distal surface of third molar to ramus)			
A	13.78 ± 4.0	7 – 25	t=8.43 p=0.000000*** sig
D	7.28 ± 4.4	1 – 16	
LES -Xi (distal surface of third molar to Xi point)			
A	31.28 ± 4.3	20 – 42	t=5.55 p=0.000000*** sig
D	26.63 ± 4.8	14 – 40	
R1 ratio (LES-R / MDW)			
A	1.04 ± 0.3	1 (0.92 – 1.14)	Z=6.84 p=0.000000*** sig
D	0.79 ± 2.02	0.57 (0.21 – 0.8)	
R2 ratio (LES - Xi / MDW)			
A	2.38 ± 0.3	2.48 (2.22 – 2.58)	Z=2.86 p=0.000000*** sig
D	2.49 ± 4.02	2.04 (1.68 – 2.23)	
α - angle (angle between axial axis of third molar and Go-Sy plane)			
A	78.58 ± 11.5	15 – 93	t=7.18 p=0.000000*** sig
D	62.53 ± 12.9	39 – 90	
β - angle (angle between axil axis of third and second molar)			
A	10.10 ± 10.97	8.5 (4.5 – 14)	Z=5.3 p=0.000000*** sig
D	20.47 ± 11.9	19.5 (10 – 27)	
γ - angle (angle between axial axis of second molar and MPl)			
A	83.80 ± 5.6	68 – 97	t=0.96 p=0.34 ns
D	84.8 ± 5.8	60 – 95	
Go – angle			
A	124.07 ± 7.3	103 – 140	t=0.92 p=0.36 ns
D	125.43 ± 8.8	106 – 143	

t (Student t-test) ; Z(Mann-Whitney U Test **p<0.01 sig ***p<0.0001

The groups with partially erupted and non-erupted molars, both with complete root formation (B and C) had significantly different linear measurements. The mesiodistal width had a significantly higher mean value (p=0.008) in group B compared to C (13.70 ± 0.9 vs 13.10 ± 1.5). LES – R and LES -Xi parameters also had a significantly higher average value (p=0.00005 and p=0.0004) in group B (10.12 ± 2.8 vs 8.0 ± 2.7, 30.60 ± 4.0 vs 27.78 ± 4.5, respectively). Groups differed significantly in α- (p<0.0001) and β-angles (p=0.00015), as well as Go angle (p=0.018), and unsignificantly for γ-angle (p=0.68). Compared values were 81.20 ± 9.6 vs 53.63 ± 27.9 for α-angle; 14.17 ± 8.5 and 31.95 ± 23.9 for β-angle and 118.57 ± 6.8 and121.62 ± 7.1 for Go angle. The R1 ratio (LES-R/MDW) had a significantly different value (p=0.0006), while R2 ratio (LES-Xi/MDW) was statistically unsignificant (p=0.06) (table no.4).

Table no 4. Descriptive statistics for linear and angular measurements and ratios among groups B and C

groups	descriptive statistics		**P value**
	mean ± SD	min - max	
mesiodistal width of the third molar			
B	13.70 ± 0.9	11 – 15	t=2,7 p=0.008** sig
C	13.10 ± 1.5	9 – 15	
LES - R (distal surface of third molar to ramus)			
B	10.12 ± 2.8	3 – 14	t=4.21 p=0.00005*** sig
C	8.0 ± 2.7	1 – 14	
LES -Xi (distal surface of third molar to Xi point)			
B	30.60 ± 4.0	22 – 37	t=3.63 p=0.0004*** sig
C	27.78 ± 4.5	16 – 36	
R1 ratio (LES-R / MDW)			
B	0.74 ± 0.2	0.77 (0.6 – 0.92)	Z=3.43 p=0.0006** sig
C	0.91 ± 0.2	0.62 (0.47 – 0.77)	
R2 ratio (LES - Xi / MDW)			
B	2.23 ± 0.2	2.23 (2.08 – 2.43)	Z=1.89 p=0.06 ns
C	2.12 ± 0.3	2.23 (1.92 – 2.33)	
α - angle (angle between axial axis of third molar and Go-Sy plane)			
B	81.20 ± 9.6	43 – 90	t=7.25 p=0.000000*** sig
C	53.63 ± 27.9	4 – 90	
β - angle (angle between axil axis of third and second molar)			
B	14.17 ± 8.5	11 (9.5 – 20)	Z=3.79 p=0.00015*** sig
C	31.95 ± 23.9	24.5 (14 – 48.5)	
γ - angle (angle between axial axis of second molar and MPl)			
B	83.57 ± 6.0	70 – 90	t=0.4

C	83.97 ± 4.6	71 – 90	p=0.68 ns
Go – angle			
B	118.57 ± 6.8	110 – 140	t=2.4 p=0.018* sig
C	121.62 ± 7.1	107 – 135	

t (Student t-test) ; Z(Mann-Whitney U Test *p<0.05 **p<0.01 sig ***p<0.0001

IV. Discussion

In this study, the anthropological distances, diamethers and angles of third mandibular molars were examined, to evaluate which parameters could predict the possibility of MM3 eruption. Changes in the position and available eruption space do have direct impact on risk for eruption. Overall reduction of retromolar space and angle between third and second molar was highly significant in all subgroups with unformed and non erupted third molars, as well as high significant third molar mesial inclination.

In treatment planning, the orthodontist often faces a major challenge in term of predicting the probability of eruption of MM3 in young patients. This prediction is accompanied by great uncertainty and has exceptional clinical significance. It is mostly based on radiographic assessment, where there is a possibility to ambiguous answers to obtained.[19] There are presented different methods for predicting the eruption of the third molars.[4,6,10,11,22,23,24] Most of the studies are based on lateral cephalograms, but also bitewing, periapical, panoramic and frontal radiographic images. Because panoramic tomograms are readily available to most dentists, it would be useful if they could be used for predicting the MM3 development.[25]

The significance of few evaluated parameters in our research indicate that several factors play a role in the potential for impact and third molar impaction is complex multifactorial mechanism.

The present research showed that retromolar space is significantly reduced in all subgroups with not formed and erupted MM3.

Insufficient development of the retromolar space, was thought as the most important factor contributing to the high rate of MM3 impaction.[8-10]

Many publications refer that probability of eruption is greater with increasing space, impaction is more likely to occur with delay physical maturation and correspond with restriction of mandibular growth, and thus a reduction in retromolar space.[10] Ganss reported that when the retromolar space is 13.9 mm in women and 14.3 mm in men, the probability of an outbreak is 70%.[26] According to Steinhardt, an increase in the surface area of this segment can be expected until the development of MM3, when one third of its roots are mineralized and deviations from the normal eruptive path were observed only in wisdom teeth with a pronounced primary ectopic position of the folicule.[27]

Ganss[26] and Niedzielska[28] did not find a significant increase in retromolar space after 16 years, while Chen[29] obtained data on moderate expansion over a period of 16-18 years. It is possible that such extension is associated with resorption of the anterior margin of the mandibular ramus, which is supported by the fact that the increased SN/MP angle is associated with higher values of retromolar space, space/width ratio and α - angle.[7,30] Janson indicates that the available retromolar space vary between Class I and Class II, suggesting that sagittal skeletal relationships also affect the fate of these teeth.[16] Greater presentation of MM3 impaction was observed in subjects with malocclusion Class II.[31] Behbehani and coworkers found that in the cases where premolar extraction was performed, MM3 impaction decreased for 63%.[7]

One study showed a significant correlation between coronoid and total ramal height with the retromolar space dimensions. The same tendency could be applied to the notch depth of the posterior and anterior margins of the ramus, the inclination of the lower posterior teeth and the mesiodistal diameter, which showed a significant correlation with the retromolar space.[32]

Turely concluded that the most useful measurement was the distance from the “Xi” to the distal surface of the second molar.[33] Rickett's Xi- point as the center of the ramus and the physiological center of occlusion, is a stable landmark during mandibular growth and can be accurately determined. For these reasons, for space analysis, its superiority over the measurement from the anterior border of the ramus was proposed, since the anterior ramus border could be resorbed during mandibular growth as a mechanism for retromolar space development.

In our study, we observed gradual decrease in LES -Xi value in the partially erupted and non-erupted groups than in the fully erupted group, so the chances of impaction increase. The study also showed lower values for this parameter, unlike Quiros[34] and Uthman[6] which estimates higher dimensions. This can also be attributed to differences in case selection, racial characteristics,[35] definition of landmarks or different measurement techniques.[6]

Ramus dimensions, as ramus height, condyle and coronoid length were significantly longer in the eruption group,[32] which does not agree with the result of Capelli, according to whom a long-growing ramus is also indicative of the impaction of MM3.[13] Several studies confirm that impaction of third molars was accompanied by significantly shorter mandibular length.[36-39] The cases with narrow mandible and small mandibular angle are almost always associated with third molar retention, estimated at the age of 18 years.[11] The rate of impaction was significantly higher in adults with Class II compared with Class III[30] and inclination is higher with anterior facial rotation.[18]

Delayed development of the third molar root is associated with impaction, too. A tooth with 1/4 of the root length at age 15, is approximately four times more likely to erupt than a tooth with initial root formation at age 15. But the root growth rate at the age of 15–20 years was less important than the developmental stage at the age of 15 years.[5] Köhler et al. describe that MM3 impaction can delay root development by 2-3 years.[40] In our subjects, in D group, the third molars are clinically invisible, and radiographically they do not have the entire root formation, despite the average age of 20 years and 9 months. Friedrich repeated this study and found that impaction had no significant relationship with root formation rate.[41] The results may not match because the groups are heterogeneous in sagittal class and jaw size. Another studies confirmed that the erupted third molars were at a somewhat more advanced stage of development at a younger age,[5] late mineralization and delayed root development were associated with a high risk of impaction.[20,21] Legovic confirm the differences between the Croatian and Spanish populations regarding the mineralization of the third molar crown according to Nolla's method, which is earlier in Croatian subjects (13.5 years), and corresponds to the Austrian and German results.[42-44]

Our research showed that paramethers for determining tooth inclinations, α - and β -angles, as well as gonial angle, along with space parameters, are measures of great importance and can be applied as prediction parameters for the third molar eruption.

During tooth development, as α angle decreases, the chances of impaction increase. For a successful eruption of the lower third molar, the α angle should be greater than 40 ° at the age of 10, so this angle will increase successively until it becomes close to the right angle when the lower third molar is completely erupted.[11,45] Uthman's research showed that the values of the α-angle for a successful eruption are 80-81°, with a large variation for boys and girls,[6] with which we also agree according to our results. Some authors argue that a lower angle in the early stages of development is a sign of its impaction.[17,18] It has been shown that the greater inclination of the posterior teeth, is greater risk of impaction.[4,8,9,30,46,47] The average values of the α, γ and gonial angles were the highest in the subjects of class III, and the lowest in the subjects of class II, except for β, whose values were completely reversed.[30] We support Turkoz, who stated that the corresponding angles α and β can reflect the external force required to reshape the retromolar region.[48]

Richardson points out that excessive initial MM3 mesial angulation and the insufficient growth of the mandible in sagittal, the reduced length of the mandible, can increase the probability of impaction of the lower third molars.[11]

The β-angle showed a significant increase in value for partially and fully impacted teeth. This difference could be related to the fact that the MM3, which are mesial inclinated, cannot fully erupt into the oral cavity, and remain partially erupted or fully impacted.

A Belgian study finds that an angle greater than 27° was unfavorable for eruption,[49] comparing Nance's conclusion that an angle greater than 35° is unfavorable and that only 3% of third molars over 35° can erupt to the occlusal plane in future 2.2 years.[50] For a successful eruption, β-angle was with minimum 9–13° or less,[6] and Haavikko states that "the initial β-angle shows a tendency to decrease and transition to a parallel or distal angle"[17] which supports the results of our study for this angle.

The γ-angle showed the least variations in all examined groups and MM3 eruption can not be predicted from the second molar position, which is consistent with other researchers.

Go – angle Skeletal Class II with shorter, narrower, sharp-angled mandible is associated with impacted third molars.[11,13] Contrastly, another authors observed no correlation between Go-angle and the impaction of MM3.[8,51] However, Tsai[52] reported a lower internal Go-angle in the eruptive group as opposed of Behbahani[7] who defined as a risk factor for impaction. A reduced gonial angle was significantly associated with a deeply impacted MM3 in the ramus, and a progressive decrease assumed a more horizontal position closer to the mandibular canal.[53]

This study did not show a definite correlation between Go-angle size and impaction. A smaller Go-angle was more common among members of the affected group, but a tendency was not detected in our D group. Our finding is consistent with the results of previous studies, that Go-angle may sometimes be associated with an increased risk of impaction.[7-9,11,26,39]

Mesiodistal width was signigicantly increased only in subgroup with partially erupted MM3. Several studies on different etnic groups, have shown higher values of the mesiodistal width of the impacted MM3, due to the different panoramic technics used.[11,15,16,34]

R1, R2 ratio The dimensions of the the space/width ratio, was significantly greater in the subjects with erupted MM3. In many studies, the lack of retromolar space and the space/width ratio was presented as most important factors which led to a high rate of impaction of mandibular third molars.[8,15,30,32] These results are consistent with the results in our study. Although the ratio space/width can increase up to 18 years, such a phenomenon has not been observed in all skeletal classes.[30] Only 2% of women had an MM3 impaction despite a ratio of more than 1. In men, all third molars were erupted when the ratio was greater than 1.[51] According to Gaans,[26] when the R1 ratio is at least 1, only 69% of the third molars erupt, a finding that is inconsistent with Al-Gunaid[32] and ours.

Furthermore, Chaturvedi et al. observed significantly larger retromolar space dimensions and space/width ratio at the subgroup of adult subjects in relation of respondents of younger age[31], consistently with Chen[29] who indicate that the posterior mandibular arch increases after the age of 16 years and prediction should be based on age and sex.

V. Conclusions

The conclusions drawn from this study are that the possibility of MM3 eruption depends on several factors and different relationships might have an impact on this process. Tooth inclination (angles α and β) as well as gonial angle, along with space parameters, are measures of great importance for predicting the eruption of the third molar. Retromolar space was significantly higher in the eruptive group. Decreased LES (LES -R and LES -Xi) and decreased space/width ratio, leads to an increased degree of impaction and are a good radiographic predictor for estimation the MM3 impaction. Mesiodistal width of the third mandibular molar is not factor in predicting impaction.

Funding Information
No funding was received for this article.

Conflict of interest
The authors declare no conflict of interest related to this study.

Author's contribution: Each author has met the authorship requirements. **B.Dz.** - conceived the study, acquisition of data and drafting the article; **M.J.H.** - data collection, analysis and interpretation of data, drafting the article; **N.T.S.** - drafting the article; **V.R.N.** - constructive feedback and editing; **Lj.S.** - interpretation, critical review; **S.P.** - interpretation, critical review; **V.R.** - interpretation, critical review.

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