ORIGINAL RESEARCH

Positional Changes with Respect to Unerupted Mandibular Third Molars in Young Adults - A Prospective Clinical Study

Kritant Bhushan[1], Rajnish Sahu[2]

ABSTRACT

Aim: The aim of this clinicoradiographic study was to observe changes in position and eruption of unerupted mandibular third molars (M3s) so that decision can be taken whether the M3 in question should be retained or removed.

Materials and Methods: A total of 50 patients of both genders with age group 18–22 years participated in the study. Panoramic radiographs were taken at the time of baseline evaluation and in every 6 months interval until 2 years later under standardized conditions. Radiographic and follow-up periodontal data were included in this analysis. Tracing of radiograph was done to evaluate changes in angular position, eruption status, and root formation of unerupted mandibular M3.

Results: During 2-year follow-up it was observed that there were statistically significant changes present in sagittal angulation of each type of unerupted mandibular M3 except in distoangular teeth. There was significant number of teeth achieved Level A eruption from Level B and C. The number of teeth with complete root formation increased at the end of the study. There was a significant association between probing depth (PD) and level of eruption.

Conclusion: The result of our study suggested that 53.3% of unerupted mandibular M3 became upright, and 13.3% showed changes toward a vertical position. Among unerupted mandibular M3 20% erupted to Level A from Level B and C. However, PD ≥4 mm in the M3 region is common clinical finding, limiting the usefulness of these M3 over the lifetime of affected patients. Therefore, regular follow-up with radiographic and clinical checkups is therefore recommended to avoid untoward sequelae when M3s are deliberately retained.

How to cite this article: Bhushan K, Sahu R. Positional Changes with Respect to Unerupted Mandibular Third Molars in Young Adults - A Prospective Clinical Study. Int J Prev Clin Dent Res 2018;5(1):S25-32.

Source of support: Nil

Conflicts of interest: None

[1,2]Oral and Maxillofacial Surgeon

[1]Oral and Maxillofacial Surgeon, Military Dental Centre, Bhopal, Madhya Pradesh, India

[2]Oral and Maxillofacial Surgeon, Dental and Facial Plastic Centre, Kanpur, Uttar Pradesh, India

Corresponding Author: Dr. Kritant Bhushan, Military Dental Centre, Bhopal, Madhya Pradesh, India. e-mail: Kritant83@gmail.com

INTRODUCTION

The development of third molars (M3s) and their influence on the dental arch are of major concern in clinical dentistry.[1] M3 eruption is an unpredictable event although the average age for the eruption of M3 is considered 20 years, ranging from 14 to 24 years.[2] M3s account for 98% of all impacted teeth and permanent mandibular M3 is the most commonly impacted tooth after maxillary M3.[3] Unerupted mandibular M3s have been associated with various pathological conditions, and mesially or horizontally impacted mandibular M3s may have an impact on mandibular incisor crowding and the stability of orthodontic treatment.[3] It was estimated that about one-fourth of mandibular M3s were removed prophylactically and more than half of the surgically removed mandibular M3s (54%) present no subjective symptoms.[3]

Longitudinal studies on positional changes and eruption of M3 indicating that some unerupted M3s do reach the occlusal plane in the third decade of life.[2] Erupted mandibular M3s were more likely to have periodontal probing equal to or more than 4 mm, limiting the usefulness of these M3s over the lifetime.[4]

In this prospective study, we will establish judgment policy with the knowledge on the fates of mandibular M3 after early adulthood. To predict changes in position and eruption status of unerupted mandibular M3 because M3 retention might be beneficial for orthodontic anchorage, prosthetic abutments, or transplant. In addition, extraction of mandibular M3 after complete eruption reduces the intensity of the surgical procedure, thereby decreasing morbidity.[3]

The existing literatures in this regard have not combined periodontal health assessment in a single study also the evaluation was done only at the end of the study. Hence, we believe there is a need for a study that combines not only positional changes in the unerupted mandibular M3s but also evaluates periodontal health around the unerupted mandibular M3s at regular time intervals during the study period.

This study evaluated the changes in position and eruption of unerupted mandibular M3s, to help us decide whether the M3 in question should be retained or removed.

MATERIALS AND METHODS

The patients were screened for unerupted mandibular M3s. The patients who were found eligible and willing for the study were informed of the study protocol, and written consent was obtained before the sampling procedure was performed. Thus, 50 patients were selected as the study subjects. A standard pro forma was used to collect necessary information regarding each subject after inclusion.

Inclusion Criteria

The following criteria were included in the study:

1. Age group ranging from 18 to 22 years.
2. Participants who had come for diagnostic checkup with full complement of permanent teeth and the unerupted mandibular M3s.

Exclusion Criteria

The following criteria were excluded from the study:

1. Participants undergoing orthodontic treatment or having the previous history of orthodontic treatment.
2. Patient with any previous history of injury to the mandible.

Panoramic radiographs were taken at the time of baseline evaluation and in every 6 months interval up to 2 years later under standardized conditions. Radiographic and follow-up periodontal data were included in this analysis.

Tracing of radiograph on 0.3 mm acetate sheets with a 0.3 mm lead pencil was done to evaluate changes in angular position, eruption status, and root formation of unerupted mandibular M3s.

Parameters Examined

Angulation of the M3

Angulation of the unerupted mandibular M3 was determined by its sagittal relationship to the adjacent second molar (M2) obtained from acetate paper tracing of standardized panoramic radiographs. A line was drawn through the midpoint of the occlusal surface and bifurcation of the M2 and M3. These lines present the long axes of the teeth. The angle formed between the intersected long axes gave the degree of M3 inclination relative to the M2. It was divided into 4 following groups as per the guidelines for angulation given by Hugoson A, Kugelberg CF:[5]

a. Vertical when angle ranges from 0° to 25° [Figure 1]
b. Mesioangular when angle ranges from 26° to 75°[Figure 2]
c. Horizontal when the angle is more than 75° [Figure 3]
d. Distoangular when angle <0° [Figure 4]

Figure 1: Vertical impaction

Figure 2: Mesioangular impaction

Figure 3: Horizontal impaction

Figure 4: Distoangular impaction

Eruption status

Eruption status of the unerupted mandibular M3 was determined by comparing its highest part with the occlusal plane and cervical line of the mandibular M2

by acetate paper tracing of the standardized panoramic radiograph; it was divided into 3 levels as per the classification of impacted M3s given by Pell and Gregory (1933):

Level A: The highest part of the M3 was on the same level or above the occlusal plane of the adjacent M2 [Figure 5].

Level B: The highest part of the M3 was below the occlusal plane but above the cervical line of the M2 [Figure 6].

Level C: The highest part of the M3 was beneath the cervical line of the M2 [Figure 7].

Root formation

Root formation was determined by acetate paper tracing of standardized panoramic radiograph of unerupted mandibular M3, was classified as: Complete root formation and incomplete root formation.

Periodontal probing

Periodontal probing was done using Williams periodontal probe at every 6 months interval until 2 years later. Probing was done at 6 sites per tooth, including M3s. These sites are mesiobuccal, buccal, distobuccal, mesiolingual, lingual, and distolingual.[5]

Considering any periodontal probing depth (PD) ≥4 mm on the distal of M2 or around M3 as suggestive of periodontal pathology associated with that M3 region,[4] the frequency of PD ≥4 mm for each M3 region was tabulated by the follow-up M3 angulation and position.

Statistical Analysis

Paired *t*-test and Chi-square test were used.

RESULTS

During the 2-year observation period, 4 of the 50 patients had undergone extraction because of recurrent pericoronitis and pain hence excluded, 3 underwent for orthodontic treatment hence excluded, and 3 patients lost for follow-up hence excluded. This study was conducted with 40 patients out of which 35 patients with bilateral, i.e., 70 teeth and 5 patient with unilateral, i.e., 5 teeth, with a total number of 75 unerupted mandibular M3s.

It was observed that 4 teeth belonging to distoangular and 3 teeth belonging to the mesioangular group had metamorphosed into the vertical group. Thus, the number of teeth in vertical increased from 35 to 42. No significant changes were observed in the horizontal group.

A paired *t*-test was done to assess the changes in angulation over a period of 2 years. There was statistically significant difference present in angulation of each type of unerupted mandibular M3s except in the horizontal group at the end of the study. All values in red are significant.

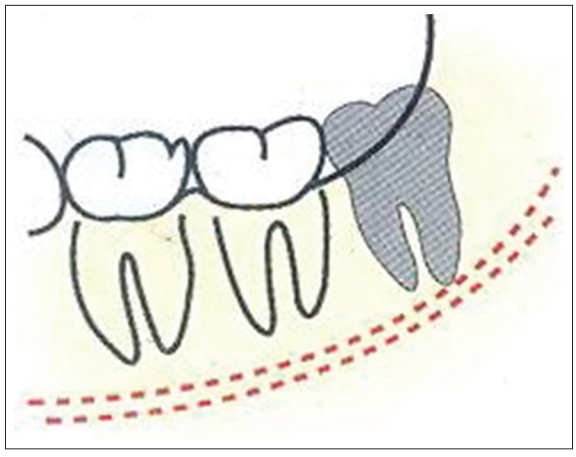

Figure 5: The highest part of the M3 was on the same level or above the occlusal plane of the adjacent M2

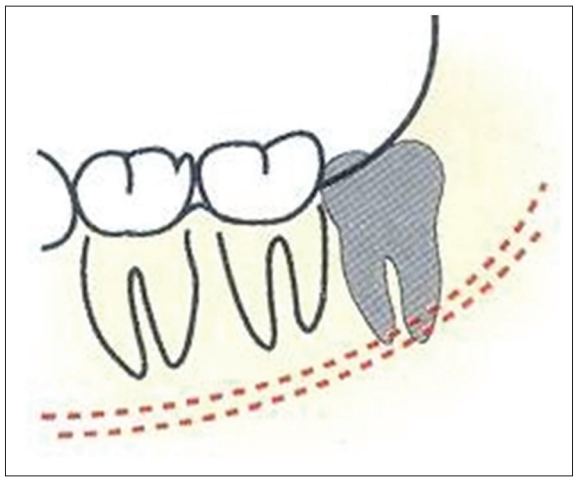

Figure 6: The highest part of the M3 was below the occlusal plane but above the cervical line of the M2

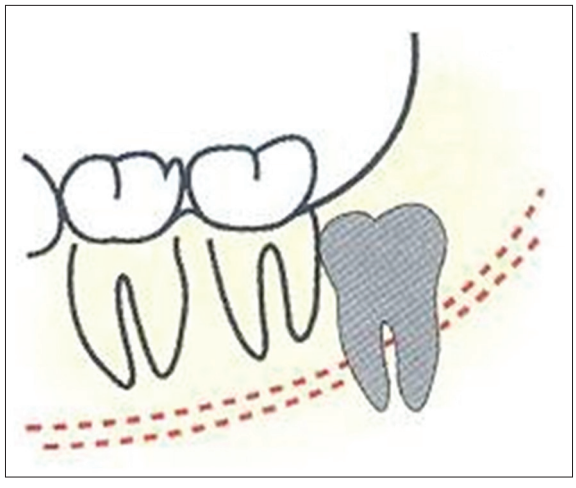

Figure 7: The highest part of the M3 was beneath the cervical line of the M2

Based on criteria of PD the unerupted M3s were broadly classified into 2 groups, 1- insignificant PD (<4 mm) and 2 - significant PD (≥4 mm); the teeth

Table 1: Comparison of the angulation during the follow-up period

Type of angulation	Angulation: At base line values	Angulation: 6 months	Angulation: 1 year	Angulation 1.5	Angulation: 2 year
Distoangular					
n	19	19	18	17	15
Mean±SD	–5.5789±20.39421	–4±18.82079	–1.1579±18.98322	–0.6316±16.8299	0.0526±15.46492
Angle change		1.5789	4.421	4.9473	5.6315
Horizontal					
n	5	5	5	5	5
Mean±SD	84.4±5.12835	83.2±6.37966	80.2±5.06952	82.2±7.69415	83.2±9.0111
Angle change		88.7789	–4.2	–2.2	–1.2
Mesioangular					
n	16	16	15	15	13
Mean±SD	31.8125±18.21801	30.625±19.18984	29.5±20.33716	30.25±19.19896	28.125±20.16887
Angle change		36.2039	–2.3125	–1.5625	–3.6875
Vertical					
n	35	35	37	38	42
Mean±SD	12.2571±10.68903	10.8286±10.37952	10.8±10.97805	10.4571±10.29661	9.2571±10.68628
Angle change		16.4075	–1.4571	–1.8	–3

belonging to these groups were further classified into Group A, B, and C according to their eruption status.

It was observed that the teeth belonging to Group B were seen to have the highest frequency of significant PD. The teeth belonging to Group C had least frequency of significant PD, and those in Group A had none with significant PD.

DISCUSSION

M3 is most commonly impacted tooth in the oral cavity which accounts for 98% of all impacted teeth.[2] Sometimes it may remain asymptomatic but most of the times it can cause pain, recurrent pericoronitis, caries to adjacent tooth and later, if not treated can give rise to the development of cyst and space infections. Due to these, surgical removal of M3 is one of the most frequently performed procedures in the oral and maxillofacial surgery. However, assessment of the germ position and prognosis of its eruption is necessary for better patient management.[3]

A school of thought states that removal of M3 at an early age seems to have less surgical and post-operative complications and hence their early prophylactic removal is frequently advised.[3] On the contrary, prophylactic removal of an M3 for fear of the above-mentioned complications is also not justified because they account for only 1–12% of problematic eruptions; i.e., the risk of development of these complications is negligible.[2]

This study, with the help of certain variables associated with an unerupted mandibular M3s, help to determine the prognosis of the unerupted mandibular M3 by foreseeing complications, thereby helping us to arrive at a conclusion whether the M3 should be retained or removed.

Angulation of Unerupted Mandibular M3s

In many studies, the angulation of impaction was usually established by winter's classification, which lacked a precise system for classifying the angulation of the unerupted M3s. Thus for the purpose of clarity in our study, we followed Hugoson and Kugelberg[5] guidelines for angulation, it was divided into 4 following groups: Vertical when angle ranges from 0^0 to 25^0, mesioangular when angle ranges from 26^0 to 75^0, horizontal when angle is $>75^0$, and distoangular when angle $<0^0$ [Table 1].

In the present study, during the 2-year observation period, the highest number of mandibular M3s was in vertical position (35, i.e., 46%), followed by mesioangular, distoangular, and horizontal position. Results of the present study are in accordance with the study of Kahl *et al*.[6] as they also found the highest number of vertically placed M3s followed by mesioangular, distoangular, and horizontal M3s. Gupta *et al*.[7] and Sandhu and Kaur[2] also found the highest number of vertically placed M3s in their study.

In the present study, 21% of the teeth changed their sagittal inclination, 53% showed uprighting changes (decrease in angulation), 14% became more deeply inclined, and 10% did not change their angulation in the mandible. Sandhu and Kaur[2] studied radiographic changes in 43 students (mean age 19.1 years) and found that 15% of the teeth changed their sagittal inclination, 49% showed uprighting changes, 32% became more deeply inclined, and 4% did not change their angulation in the mandible over a period of 4 years. Their study

Table 2: Comparison of the angulation of M3 in relation to M2 during the observation period

Angulation: 0	Mean	*n*	SD	Mean	SD	*t*	df	*P* value
Distoangular								
Pair 1								
Angulation: 0 values	–5.5789	19	20.39421	–1.57895	2.83462	–2.428	19	0.209
Angulation: 6 M values	–4	19	18.82079					
Pair 2								
Angulation: 0 values	–5.5789	19	20.39421	–4.42105	19.38589	–0.994	18	0.333
Angulation: 1-year values	–1.1579	18	18.98322					
Pair 3								
Angulation: 0 values	–5.5789	19	20.39421	–4.94737	18.97505	–1.136	17	0.101
Angulation: 1.5-year values	-0.6316	17	16.8299					
Pair 4								
Angulation: 0 values	–5.5789	19	20.39421	–5.63158	18.20931	–1.348	15	0.026
Angulation: 2-year values	0.0526	15	15.46492					
Horizontal								
Pair 1								
Angulation: 0 values	84.4	5	5.12835	1.2	3.03315	0.885	5	0.426
Angulation: 6 M values	83.2	5	6.37966					
Pair 2								
Angulation: 0 values	84.4	5	5.12835	4.2	1.09545	8.573	5	0.201
Angulation: 1-year values	80.2	5	5.06952					
Pair 3								
Angulation: 0 values	84.4	5	5.12835	2.2	3.34664	1.47	5	0.216
Angulation: 1.5-year values	82.2	5	7.69415					
Pair 4								
Angulation: 0 values	84.4	5	5.12835	1.2	4.96991	0.54	5	0.618
Angulation: 2-year values	83.2	5	9.0111					
Mesioangular								
Pair 1								
Angulation: 0 values	31.8125	16	18.21801	1.1875	3.76331	1.262	16	0.226
Angulation: 6 M values	30.625	16	19.18984					
Pair 2								
Angulation: 0 values	31.8125	16	18.21801	2.3125	10.97706	0.843	15	0.413
Angulation: 1-year values	29.5	15	20.33716					
Pair 3								
Angulation: 0 values	31.8125	16	18.21801	1.5625	5.47685	1.141	15	0.272
Angulation: 1.5-year values	30.25	15	19.19896					
Pair 4								
Angulation: 0 values	31.8125	16	18.21801	3.6875	6.95432	2.121	13	0.001
Angulation: 2-year values	28.125	13	20.16887					
Vertical								
Pair 1								
Angulation: 0 values	12.2571	35	10.68903	1.42857	2.22665	3.796	35	0.201
Angulation: 6 M values	10.8286	35	10.37952					
Pair 2								
Angulation: 0 values	12.2571	35	10.68903	1.45714	5.34868	1.612	37	0.116
Angulation: 1-year values	10.8	37	10.97805					
Pair 3								
Angulation: 0 values	12.2571	35	10.68903	1.8	5.47615	1.945	38	0.006
Angulation: 1.5-year values	10.4571	38	10.29661					
Pair 4								
Angulation: 0 values	12.2571	35	10.68903	3	5.59937	3.17	42	0.003
Angulation: 2-year values	9.2571	42	10.68628					

Angulation: 0: At baseline, 6M – At 6, M2: Second molar

included erupted teeth as well (as the present study does not). Hattab *et al*.[1] found that 44% of teeth became vertical, 34% showed uprighting changes, 7% became deeply inclined, and no change in angulation was seen

Table 3: Comparison of the eruption status with periodontal probing at baseline

At start PD *ES cross-tabulation				
PD	**ES**			**Total**
	A	**B**	**C**	
At baseline (PD)				
Insignificant				
Count	34	24	2	60
% within ES	100.0	63.2	66.7	80.0
Significant				
Count	0	14	1	15
% within ES	0.0	36.8	33.3	20.0
Total				
Count	34	38	3	75
% within ES	100.0	100.0	100.0	100.0

ES: Eruption status, PD: Probing depth

in 15% of teeth during the 4-year observation period. According to Ventä *et al*.[9] (mean age at baseline 20.7 years), 76% of the 21 impacted mandibular M3s (both in mesial and distal angulation) changed their sagittal inclination over a period of 12 years. Nance *et al*.[4] in their study of 237 patients (median age 25.9 years) also showed that 26% of impacted mandibular M3s change angulation or position after a follow-up period of 2.2 years.

In our study population, 3 of 16 (18.75%) unerupted mesioangular teeth became vertical during follow-up, while 6 (37.5%) teeth showed uprighting changes, 2 (12.5%) became more deeply inclined, and 2 (12.5%) did not change. 4 of 19 (21%) unerupted distoangular teeth became vertical, while 10 (52.6%) teeth showed uprighting changes, 3 (15.7%) became more deeply inclined, and 2 (10.5%) did not change during 2-year follow-up [Tables 2 and 3].

Level of Eruption

The level of impaction with respect to bone gives a direct indication of the depth to which the tooth is buried. In our study Level B was most common (52%), followed by Level A (44%) and Level C (4%). Level of eruption in the present study is in agreement with that of Quek *et al*.[10] Hassan,[11] Padhye *et al*.,[12] found maximum M3s at Level B followed by Level A and Level C. In our study, the Level A position was more frequent within vertical impaction followed by distoangular, mesioangular, and horizontal. Almost similar results have been reported by Nance *et al*.,[4] Padhye *et al*.,[12] and Sandhu and Kaur.[2]

In our study, among 35 (i.e., 46.6%) of impacted vertical teeth, 17 (i.e., 48.5%) were at Level A, 16 were (i.e., 45.7%) at Level B, and 2 (i.e., 5.7%) were at Level C. More than half (51.4%) of impacted vertical teeth (Levels B and C) had erupted to the occlusal plane during the 2-year follow-up period. Almost similar results have been reported by Nance *et al*.[4] in a study of 237 young adults (aged 14–45 years at enrollment with the median age at the baseline of 25.9 years). Sandhu and Kaur *et al*.[2] reported more than one-third (37.5%) of impacted vertical teeth (Levels B and C) in mandible erupted to the occlusal plane during the 4-year follow-up period.

In the present study, 31.5% of distoangular teeth erupted to occlusal level during follow-up. Richards[14] reported (mean age 18 years, period of follow-up 8 years) eruption of one-third (31.6%) of mandibular distoangular teeth. Sandhu and Kaur *et al*.[1] reported 50% of distoangular teeth in the mandible erupted to occlusal level during follow-up.

In our study population, only 2 of the 16 unerupted mesioangular (12.5%) teeth erupted to occlusal level, of which 1 tooth (6.2%) remained as mesioangular and 1 teeth (6.2%) became vertical. Nance *et al*.[4] in their study population (median age 25.9 years and period of follow-up 2.2 years) found that 11% of mesioangular mandibular M3s erupted to the occlusal plane. Hattab *et al*.[8] studied 59 mesioangular mandibular M3s in 36 students found that only 6% of mesioangular teeth erupted to the occlusal plane. These are comparable with our results and suggest that mandibular impacted mesioangular M3s are unlikely to erupt during the third decade of life.

Root Formation

The majority of permanent teeth other than M3s emerge with their roots at a three-quarters stage of development.[13] In contrast, the teeth with initial incomplete root formation in our study changed their level of eruption from Level B and C to Level A more often than teeth with initial complete root formation during the 2-year observation period. In our study, root development was incomplete in 28 of 75 (37.3%) unerupted M3s at the start of the study, in which 22 of the 28 (78.5%) developed root in 2-year follow-up. Teeth with initial complete roots (47, i.e., 62.7%) also showed sagittal angulation changes although to a slightly lesser extent than teeth with initial incomplete roots. These findings imply that although the root apex was complete at the baseline, some eruptive activity remained. Even teeth with complete root formation may move to the more advanced level of the eruption and change their sagittal angulation.[15,17,8] Almost similar results have been reported by Sandhu and Kaur.[2]

Periodontal Probing

For M3s to be clinically useful, vertical/distal erupted M3s must be free of pathology and be maintained in that state throughout life.[16] In our study at follow-up 6

of 16 (37.5%) unerupted mesioangular, 10 of 35 (28.5%) unerupted vertical, and 1 of 19 (5.2%) unerupted distoangular third molars had at least 1 PD more than or equal to 4 mm on the distal of the M2 or around the M3.

Our data indicate that more than 70% of unerupted vertical/distal M3s have minimal PD (<4 mm) at follow-up. These M3s appear to be clinically useful and could be retained and monitored over time for caries or periodontal pathology. Almost similar results have been reported by Nance *et al*.[4] where half of mandibular vertical/distal M3s have minimal PD (<4 mm) at follow-up.

How does our data affect patients decision about treatment for impacted M3s? Nance *et al*.[4] reported that if impacted M3s are angled mesial/horizontal, it is unlikely that these teeth will erupt. Kugelberg *et al*.[18] reported that mesial/horizontal impacted M3s often have PD ≥4 mm and infrabony defects between second and M3 before removal. Retaining these teeth greatly reduced the chance of the periodontal status improving with M3 removal. The prudent decision for treatment of mesial/horizontal impacted M3s seems to be removal. Conversely, if M3s are impacted in vertical/distal angulation, a period of follow-up might be prudent to see if the M3s will erupt to the occlusal plane.[19-23] However, removal of these teeth should be considered if PD ≥4 mm in the M3 region exists or develop during follow-up.[16]

The result of our study suggested that, between the age of 18 and 22 years, 53.3% (i.e., 40 out of 75) of unerupted mandibular M3s became upright, and 13.3% showed changes toward a vertical position. More of unerupted mandibular M3s with low initial inclination assumed upright position than those with greater tilt. Among unerupted mandibular M3s, 20% erupted to Level A from Level B and C, and 78.5% of unerupted mandibular M3s with incomplete root developed root at the end of the study.

CONCLUSION

The aim of this clinicoradiographic study was to observe changes in position and eruption of unerupted mandibular M3s so that decision can be taken whether the M3 in question should be retained or removed. Earlier it was believed that growth of the mandible and accompanying resorption, as well as maxillary growth, is essentially completed by 16–17 years of age, so further eruption is unlikely. Mercier and Precious [20] provided evidence that facial growth continues during adult life. Hence, the most important result of this study was that retained M3s changed their position in bone. The patients were mostly asymptomatic. Conversely, if M3s are impacted and vertical/distal, a period of follow-up might be prudent to see if the M3s will erupt to the occlusal plane.[15] However, PD ≥4 mm in the M3 region is common clinical finding, limiting the usefulness of these M3s over the lifetime of affected patients. Therefore, regular follow-up with radiographic and clinical checkups is, therefore, recommended to avoid untoward sequelae when M3s are deliberately retained.

REFERENCES

1. Hattab FN, Irbi H. Positional changes and eruption of impacted mandibular third molars in young adults a radiographic 4-year follow-up study. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1997;84:604-8.
2. Sandhu S, Kaur T. Radiographic evaluation of the status of third molars in the Asian-Indian students. J Oral Maxillofac Surg 2005;63:640-5.
3. Amin K, Vasavi K, Vahanwala S, Nayak CD, Pagare SS, Ramd SS. Co-relation of variables as′ determined from panoramic radiograph and evaluating their significance in eruption of permanent mandibular third molar. J Indian Acad Oral Med Radiol 2008;20:1.
4. Nance PE, White RP Jr., Offenbacher S, Phillips C, Blakey GH, Haug RH, *et al.* Change in third molar angulation and position in young adults and follow-up periodontal pathology. J Oral Maxillofac Surg 2006;64:424-8.
5. Hugoson A, Kugelberg CF. The prevalence of third molars in a Swedish population. An epidemiological study. Community Dent Health 1988;5:121-38.
6. Kahl B, Gerlach KL, Hilgers RD. A long-term, follow-up, radiographic evaluation of asymptomatic impacted third molars in orthodontically treated patients. Int J Oral Maxillofac Surg 1994;23:279-85.
7. Gupta S, Bhowate RR, Nigam N, Saxena S. Evaluation of impacted mandibular third molars by panoramic radiography. ISRN Dent 2011;2011:8.
8. Hattab FN, Rawashdeh MA, Fahmy MS. Impaction status of third molars in Jordanian students. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1995;79:24-9.
9. Ventä I, Turtola L, Ylipaavalniemi P. Radiographic follow-up of impacted third molars from age 20 to 32 years. Int J Oral Maxillofac Surg 2001;30:54-7.
10. Quek SL, Tay CK, Tay KH, Toh SL, Lim KC. Pattern of third molar impaction in a Singapore Chinese population: A retrospective radiographic survey. Int J Oral Maxillofac Surg 2003;32:548-52.
11. Hassan AH. Pattern of third molar impaction in a Saudi population. Clin Cosmet Investig Dent 2010;2:109-13.
12. Padhye MN, Dabir AV, Girotra CS, Pandhi VH. Pattern of mandibular third molar impaction in the Indian population: A retrospective clinico-radiographic survey. Oral Surg Oral Med Oral Pathol Oral Radiol 2013;116:e161-6.
13. Bolaños MV, Moussa H, Manrique MC, Bolaños MJ. Radiographic evaluation of third molar development in Spanish children and young people. Forensic Sci Int 2003;133:212-9.
14. Richardson M. Changes in lower third molar position in the young adult. Am J Orthod Dentofacial Orthop 1992;102:320-7.
15. Altonen M, Haavikko K, Mattila K. Developmental position

of lower third molar in relation to gonial angle and lower second molar. Angle Orthod 1977;47:249-55.
16. Kugelberg CF, Ahlstrom U, Ericson S, Hugoson A. Periodontal healing after impacted lower third molar surgery. Int J Oral Maxillofac Surg 1986;15:675-86.
17. von Wowern N, Nielsen HO. The fate of impacted lower third molars after the age of 20. A four-year clinical follow-up. Int J Oral Maxillofac Surg 1989;18:277-80.
18. Kugelberg CF, Ahlström U, Ericson S, Hugoson A, Kvint S. Periodontal healing after impacted lower third molar surgery in adolescents and adults. A prospective study. Int J Oral Maxillofac Surg 1991;20:18-24.
19. Blakey GH, Gelesko S, Marciani RD, Haug RH, Offenbacher S, Phillips C, *et al*. Third molars and periodontal pathology in American adolescents and young adults: A prevalence study. J Oral Maxillofac Surg 2010;68:325-9.
20. Mercier P, Precious D. Risks and benefits of removal of impacted third molars. A critical review of the literature. Int J Oral Maxillofac Surg 1992;21:17-27.
21. Lauesen SR, Andreasen JO, Gerds TA, Christensen SS, Borum M, Hillerup S, *et al.* Association between third mandibular molar impaction and degree of root development in adolescents. Angle Orthod 2013;83:3-9.
22. Eliasson S, Heimdahl A, Nordenram A. Pathological changes related to long-term impaction of third molars. A radiographic study. Int J Oral Maxillofac Surg 1989;18:210-2.
23. Adeyemo WL. Do pathologies associated with impacted lower third molars justify prophylactic removal? A critical review of the literature. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2006;102:448-52.