

Original article

Third Molar Impactions Prevalence and Pattern Among Adults Using 5923 Digital Orthopantomogram

Mamun Khan Sujon¹, Mohammad Khursheed Alam^{2,*}, Shaifulizan Abdul Rahman^{3,*}, Siti Noor Fazliah Mohd Noor⁴

Abstract

Background: Third molars positions and eruption patterns tend to be unpredictable in most cases. Substantial diversity exists globally among modern human races in the prevalence of third molar impaction. **Aims and Method:** This study aimed to investigate the prevalence and pattern of third molar impaction among Bangladeshi adults. Digital panoramic radiographs of 5923 patients with the mean age of 35.90 ± 10.76 years olds were retrieved from database and evaluated using Planmeca Romexis software. Demographics, gender and sidedifferences were analysed using SPSS version 26.0. **Result:** Approximately, 46.2% of the adult population had third molar impaction where significant impaction occurred in the mandible compared to maxillary arch. However, no significant differences were observed among gender and side distribution. The most common type of third molar angulation in the maxilla and mandible was distoangular (55.9%) and mesioangular (36.6%), respectively. Comprehension of demographic and morphological variations in third molar impaction will lead to an understanding of third molar impaction assessment, which will aid in understanding the evolutionary origins of an important condition adversely affecting modern peoples.

Keywords: Third Molar; Impaction; Maxilla; Mandible; Orthopantomogram

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Introduction

Third molars are commonly referred to as wisdom teeth. In modern civilization, it is the most polymorphic teeth in human dentition. Approximately half of the people across the globe having some form of an anomaly with their third molars; either it is congenitally absent in oral cavity¹, or it remains completely impacted or partially impacted². Tooth impaction is a pathological condition in which

a tooth cannot or will not erupt into its normal functioning position.³ The worldwide prevalence of third molar impaction is not constant, ranging from 7.5%⁴ to 73.5%⁵ (Figure 1). Many previous studies cited an inconsistent statement on whether third molar impaction differs by gender⁶⁻⁸, whether mandibular third molar impaction is more prevalent or maxillary third molar⁹⁻¹², in which pattern of third molar impaction is mostly seen.^{11,13}

1. Mamun Khan Sujon, Department of Dental Science, Advanced Medical and Dental Institute, Universiti Sains Malaysia, Pulau Pinang, Malaysia.
2. Mohammad Khursheed Alam, Orthodontic Department, College of Dentistry, Jouf University, Sakaka, Kingdom of Saudi Arabia and Department of Public Health Faculty of Allied Health Science, Daffodil International University, Dhaka, Bangladesh.
3. Shaifulizan Abdul Rahman, Oral and Maxillofacial Surgery Unit, School of Dental Sciences, Universiti Sains Malaysia, Kelantan, Malaysia.
4. Siti Noor Fazliah Mohd Noor¹ Department of Dental Science, Advanced Medical and Dental Institute, Universiti Sains Malaysia, Pulau Pinang, Malaysia.

Correspondence:

1. Shaifulizan Abdul Rahman, Professor, Oral and Maxillofacial Surgery Department, School of Dental Sciences, Universiti Sains Malaysia, Kelantan, Malaysia. E-mail: shaiful@usm.my
2. Mohammad Khursheed Alam, Professor, Orthodontic Division, Preventive Dentistry Department, College of Dentistry, Jouf University, Sakaka, Kingdom of Saudi Arabia. Department of Public Health Faculty of Allied Health Science, Daffodil International University, Dhaka, Bangladesh. **E-mail:** dralam@gmail.com; mkalam@ju.edu.sa

Comprehension of racial variation in third molar impaction prevalence may constitute the aetiology of impaction globally.¹⁴ Moreover, dietary habits, masticatory function, and hereditary variables may all influence the eruption of third molar and subsequent positional alterations.¹⁵ Local factors such as malposed tooth germs, supernumerary teeth, arch-length deficiency, prolonged deciduous tooth retention, cleft lip and palate are accountable for tooth impaction.^{2,3,16,17} Third molar impaction has been associated with pericoronitis, periodontitis, root resorption, cystic lesions, caries, neoplasm and would be the origin of mandibular fracture by weakening the angle of the mandible.¹⁸ Dental surgeons hold opposing viewpoints on prophylactic treatment of third molar impaction, with some advocating early treatment to avoid complications from later surgery and others arguing that treating symptomless teeth exposes patients to unnecessary risk.¹⁹

Orthopantomograph (OPG) or panoramic radiograph is secondary to intraoral radiography in the regular practise of dentistry. However, OPG imaging may be more beneficial to patients because it offers both excellent evaluations of jaw fractures, tooth development, and maxillary sinus disorders.²⁰ With the advancement of imaging technology, the role of radiology in dentistry continues to expand. In past few years, radiology has been advancing towards digitization and computerization to acquire more precise diagnosis.²¹ In contrast to film based OPG, digital OPG has advantages including a large dynamic range, reduced repeat rates, digital image storage and image manipulation in post-processing.²² The noise level reduction is another aspect to incorporate into the digitising system. The develop process of film or printing medium like electronic components of imaging system adds additional noise to the printed film, resulting in poor diagnostic quality.²² Moreover, following the trend of digitization, various commercial software tools were developed to carry out radiological investigations, alter radiographic pictures and diagnostic measurements. This offers an alternative to conventional radiography as a means of imaging. In the past years, one of a new digital radiographic software (PlanmecaRomexis® 3.0 software which is a product of PlanmecaOy, Finland.) have been developed and widely using by the researchers and clinician. PlanmecaRomexis®, a software package that can capture, examine, manipulate and process 2D and 3D radiographs. The system provides customised modules for dental

education, as well as a unique clinic administration and maintenance approach. In oral and maxillofacial surgery and endodontic treatment, working length is a crucial part for a successful treatment outcome.²¹ The authors of a validation study for PlanmecaRomexis® suggested using this software instead of manually measuring radiograph film in the illuminator as software tends to underestimate working length measurements when compared to conventional radiography film measurement systems.²¹

Due to geographical difference in the incidence and pattern of third molar impaction, the current study aims to investigate the prevalence of third molar impaction, gender disparities in third molar impaction, upper and lower jaw distribution, right and left side variances, and third molar impaction patterns among Bangladeshi population using digital images of panoramic radiograph or orthopantomogram (OPG).

Materials and Methods

Ethical approval

Radiographs were collected from the diagnostic center's archive of Dhaka, Bangladesh with prior permission from the authority for research purposes only. Prior to taking the radiographs, all participants were informed about the processes and risk associated with radiograph taking and signed a consent form (subjects under the age of 18 years gave written approval from either their parents or legal guardians). The digital radiographic images transferred to School of Dental Sciences, Universiti Sains Malaysia (USM)'s PlanmecaRomexis® 3.0 software (PlanmecaOy, Helsinki, Finland) server through e-cloud service. The research was carried out at the School of Dental Sciences, USM. The Human Research Ethics Committee (JEPeM) of USM approved this study (USM/JEPeM/15080273), which complies with the Declaration of Helsinki. This study was designed and conducted according to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines.

Sample Collection

Digital OPG of 5923 patients (2835 female and 3088 male) were collected randomly from the archive of two renowned diagnostic centres in Dhaka, Bangladesh, in February 2015.

Inclusion criteria for digital OPG images selection

- The OPG images was selected from the patients aged between 19 to 80 yearsold and had not had any teeth surgically removed or extracted.

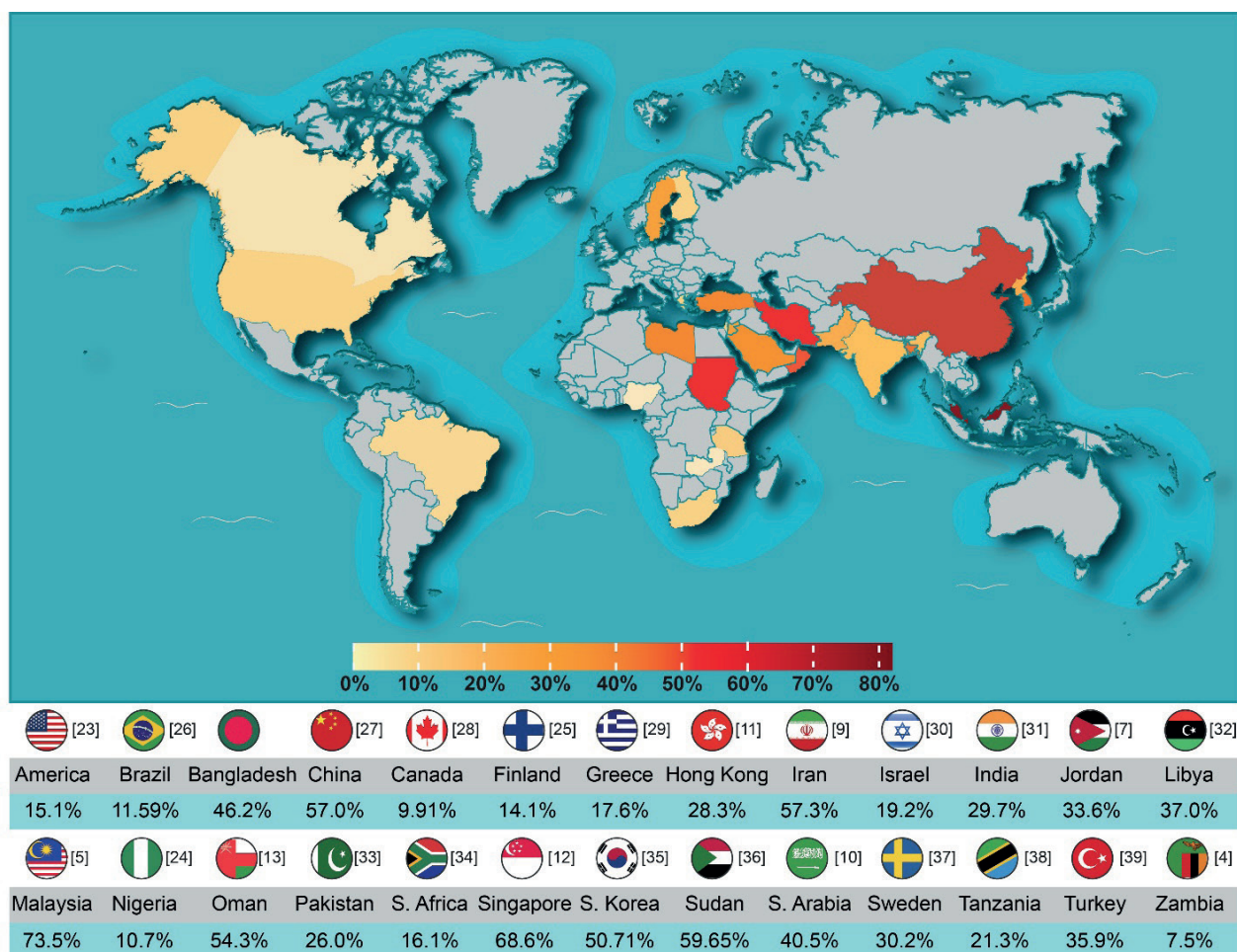


Figure 1. Choropleth map of the global frequency of third molar impaction^{4,5,7,9-13,23-39} (Illustrated using Adobe Illustrator CC 2019).

- Only radiographs images with minimal distortion and no haze were included.
- The third molar was envisaged as impaction when it had not entirely erupted to normal functional occlusion, and roots were fully formed based on the OPG.

Exclusion criteria for digital OPG images selection

- Incomplete root development of third molar.
- Agenesis of any third molar.
- Absence of adjacent second molar.
- Patients with facial clefts, or other craniofacial deformities visible in OPG.
- Patients with pathologies such as cyst, tumour etc visible in OPG.
- Incomplete patient identifying information.

Sample size calculation

In order to calculate the sample size for the prevalence of third molar impaction, the single proportion formula was used as follows⁴⁰:

$$n = \left(\frac{Z}{\Delta}\right)^2 \times P(1 - P)$$

with, n= required sample size, Z= 1.96 (95% confidence interval), Δ= Absolute precision, P is a population proportion (or prevalence) required for the study.

The population proportion was found to be 5.7% in a previous study⁴¹ with a level of significance set at 5%. The precision of this study was set at 1%. When substituted: $n = (1.96/0.01)^2 \times 0.057 (1 - 0.057) = 38416 \times 0.053751 = 2065$, hence, the minimum number of samples required to investigate the third molar impaction among adults in Bangladeshi population is 2065 radiograph samples.

A total of 5923 patient's radiographs were screened and based on inclusion and exclusion criterias, a total of 2872 (1491 male and 1381 female) radiographs (Figure 2) were selected for determination of

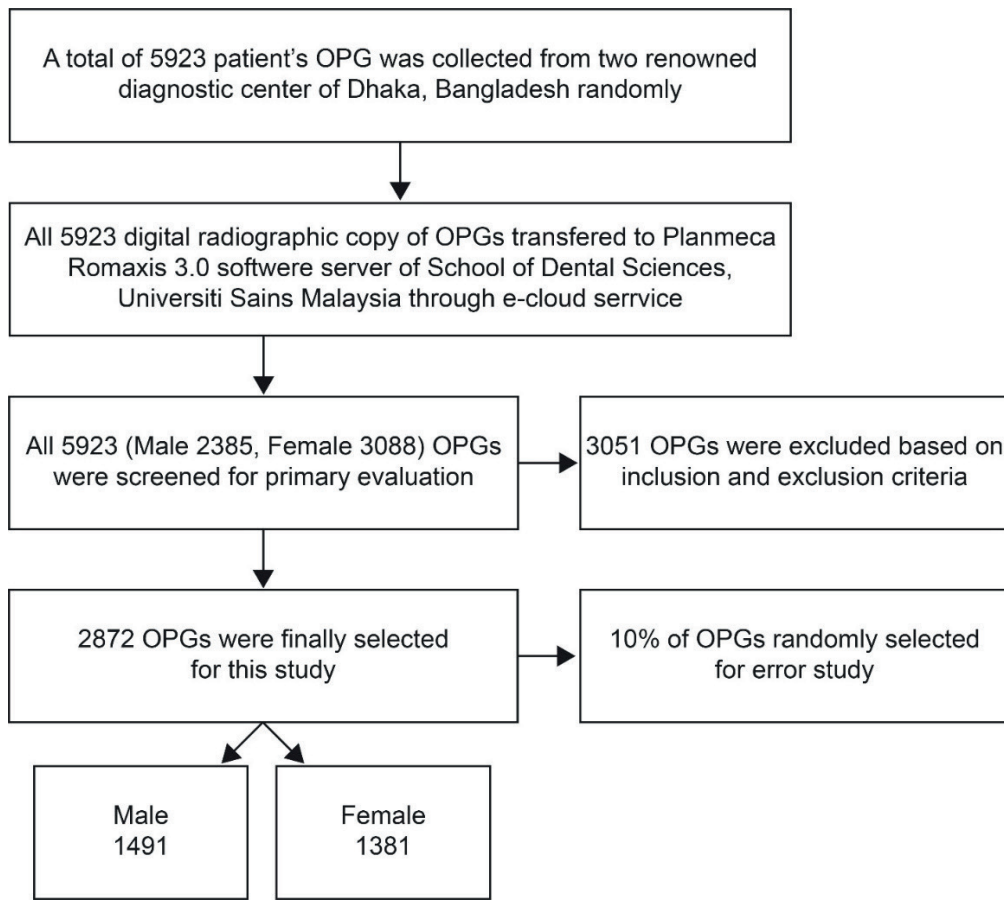


Figure 2. Flow chart of selection of OPG for this study.

prevalence and patterns of third molar impaction. The radiographs were evaluated by two investigators who had been trained and calibrated by a skilled specialist. Angle, depth, and width of impaction were examined using Planmeca Romaxis® 3.0 software (Planmeca Oy, Helsinki, Finland).

Determination of impaction angulation

Winter's⁴² classification was adopted for assessing the angulation of impaction. On the longitudinal axis of the third and second molar teeth, two vertical imaginary (red) lines were drawn, and the angle produced between these lines was measured (Figure 3). The angulations are classified into:

1. Vertical impaction: 10° to -10°
2. Mesioangular impaction: 11° to 79°
3. Horizontal impaction: 80° to 100°
4. Distoangular impaction: -11° to -79°
5. Others: 111° to -80°

Mesio-inverted, Distoinverted, Disto-horizontal and Buccolingual were combined and classified as others.

Determination of impaction depth and width

The depth and width of impaction were investigated using Pell and Gregory⁴³ classification. The depth or level of the impaction was measured in relation to bone and cemento-enamel junction (CEJ) of the impacted third molar (Figure 3).

1. Level A- Not buried in bone.
2. Level B- Partially buried in bone. (If any part of the CEJ was lower than the bone level, the tooth was considered to be partially buried in bone)
3. Level C- Completely buried in bone.

The width of the impaction was assessed in relation to the anterior border of ramus and crown of impacted third molar (Figure 3).

1. Class I- Situated anterior to the anterior border of the ramus.
2. Class II- Half of the crown is covered by the anterior border of the ramus.
3. Class III- Crown fully covered by the anterior of the ramus.

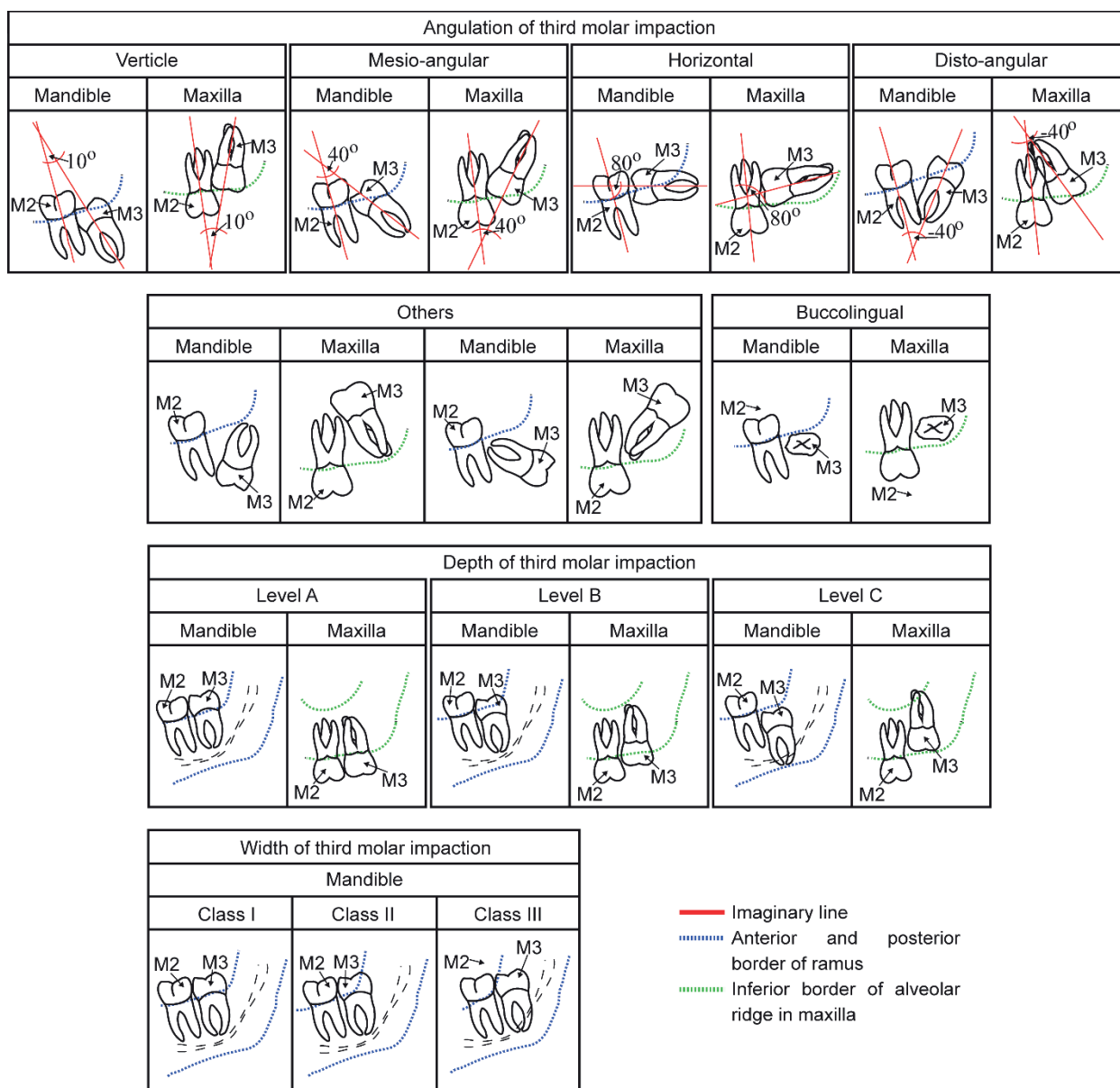


Figure 3. Determination of impaction angulation, depth, and width.

Statistical Analysis

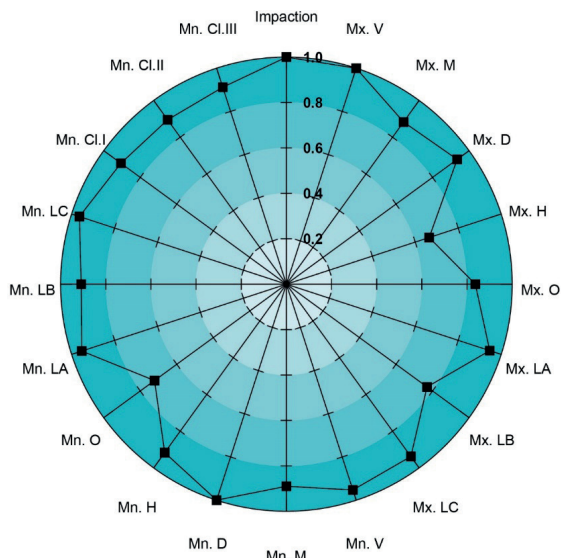
Data were analysed using IBM Statistical Package for Social Science (SPSS), Version 22.0 (IBM, USA). Categorical data for the prevalence of third molar impaction, comparison between gender, upper and lower jaw distribution, and side differences was calculated using the Pearson Chi-square test. Association between impaction patterns was conducted using bivariate correlation. A *p*-value of <0.05 was considered statistically significant.

Error of the study

Randomly selected 10% of radiographs were evaluated by another researcher two weeks after

the initial survey to determine the reliability of prevalence and pattern of the third molar impaction. Inter-examiner agreements were determined using Kappa statistics. Viera and Garrett⁴⁴ defined weak agreement as a value of <0.20, fair agreement as 0.20-0.40, moderate agreement as 0.40-0.60, substantial agreement as 0.60-0.80, and almost perfect agreement as 0.80-0.99.

The Kappa statistics (Figure 4) revealed a 100% perfect inter-examiner agreement between the investigators for the prevalence of third molar impaction. Substantially, all variables of third molar impaction pattern showed almost perfect agreement amongst the inter-examiners.



V- Vertical, M- Mesioangular, D- Distoangular, H- Horizontal, O- Others, LA- Level A, LB- Level B, LC- Level C, Cl.I- Class I, Cl.II- Class II, Cl.III- Class III, Mx- Maxilla, Mn- Mandible

Figure 4. Inter-examiner kappa value for third molar impaction and pattern of impaction.

Results

Demographic distribution and prevalence of third molar agenesis

Among the 2872 subjects examined, 1327 subjects had at least one third molar impaction (Table 1). The third molar impaction was found to be 46.2%. The frequency of subjects with two third molar impaction was higher than others. The frequency of the number of third molar teeth impaction was 2 > 1 > 3 > 4. Moreover, the subjects were divided into 5 age groups with the mean age of 35.90± 10.76 years old. The highest number of the subjects in the group of 35-54 years old. The incidence of third molar impaction in males (51.5%) were higher than in females (48.5%), although this difference was not statistically significant (*p*-value = 0.736) (Table 1).

Table 1. Demographic distribution and prevalence of third molar impaction in Bangladeshi population.

Variables		Prevalence	%	X ² statistic ^a (df)*	p value
M3 Impaction	Present	1327	46.2		
	Not Present	1545	53.8		
	Total	2872	100		
Frequency of M3 Impaction	Patients have 1 M3 Impaction	420	31.6		
	Patients have 2 M3 Impaction	777	58.6		
	Patients have 3 M3 Impaction	72	5.4		
	Patients have 4 M3 Impaction	58	4.4		
	Total	1327	100		
Age (years)	19-24	184	13.9		
	25-34	487	36.7		
	35-54	587	44.2	7.073 (4)	0.132
	55-64	52	3.9		
	65+	17	1.3		
	Total	1327	100		
Gender	Male	684	51.5		
	Female	643	48.5	0.135 (1)	0.736
	Total	1327	100		

All the counts are by the number of patients, M3= Third molar

^a= Pearson Chi-Square for independence

*df= degree of freedom

Distribution of third molar impaction between arches and side

The mandibular third molar impaction (67.0%) was more common than the maxillary third molar

impaction (19.9%), with a statistically significant difference (*p*-value < 0.001). The frequency of third molar impaction in order to sides was mandibular right > mandibular left > maxillary right > maxillary left (Figure 5).

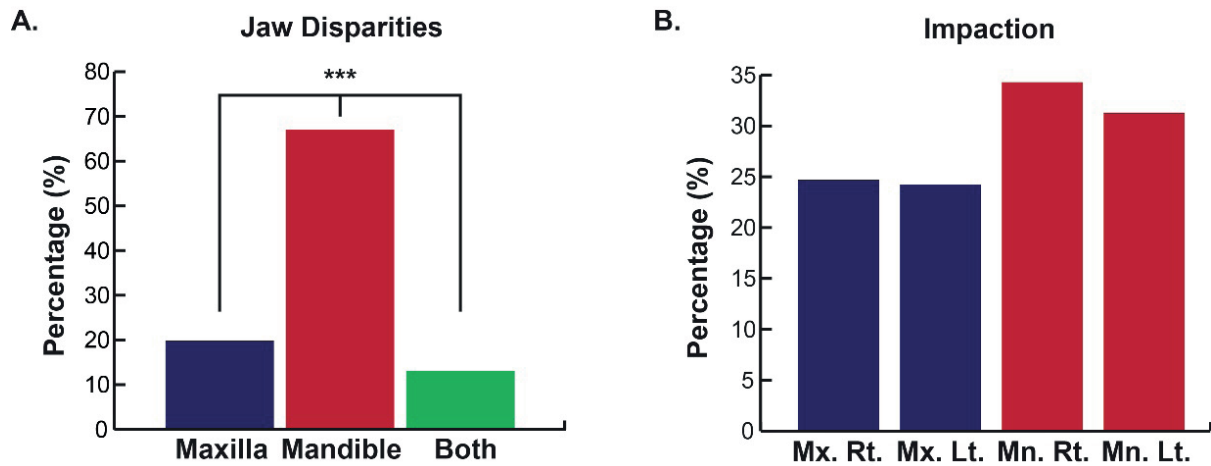


Figure 5. Distribution of third molar impaction according to jaw disparities (A), and frequency in order to sides (B).

Distribution of third molar impaction between side

Approximately 2433 third molars were recorded as impacted among 1327 (5308 third molar teeth) individuals. No statistically significant difference between the sides was recorded (p value = 0.502) (Table 2).

Table 2. Distribution of third molar according to side disparities.

	Maxilla			Mandible			Total (%)	X ² statistic ^a	pvalue ^a
	Male (%)	Female (%)	Total (%)	Male (%)	Female (%)	Total (%)			
Right	168 (6.9)	160 (6.6)	328 (13.5)	466 (19.1)	446 (18.3)	912 (37.4)	1240 (50.9)	0.013	0.502
Left	172 (7.1)	149 (6.1)	321 (13.2)	476 (19.6)	396 (16.3)	872 (35.9)			
Total			649 (26.7)			1784 (73.3)	2433 (100)		

^a = Pearson Chi-Square for between sides

Distribution of third molar impaction pattern Among 2433 impacted third molars a significant correlation was found between angular position and jaw, mesioangular (36.55%, p -value<0.001) impaction was more common in mandibular arch and distoangular (55.9%, p -value <0.001) impaction was more common in maxillary arch. Moreover, the depth of impaction and the type of arches were

also shown to have a significant relationship. In the maxillary arch, Level C (78.1%, p -value<0.001) was more prevalent, while in the mandibular arch, Level A (62.2%, p -value <0.001) was more common. The most frequent impaction position concerning ramus of the mandible was Class I, followed by Class III and Class II (Table 3).

Table 3. Distribution of angulation and depth of third molar impaction.

	Maxilla			Mandible			Total(%)
	Impaction Present (%)	X ² statistic ^a	pvalue ^a	Impaction present	X ² statistic ^a	pvalue ^a	
Angulation							
Vertical	48(7.4)	0.270	0.000	521(29.2)	0.455	0.000	569(23.4)
Mesioangular	147 (22.7)	0.529	0.000	652 [#] (36.55)	0.536	0.000	799 (32.8)
Distoangular	363 [#] (55.9)	0.656	0.000	1(0.05)	0.024	0.000	364(15)
Horizontal	25(3.9)	0.168	0.000	565 (31.7)	0.486	0.000	590 (24.2)
Others	66(10.1)	0.293	0.000	45(2.5)	0.165	0.000	111 (4.6)
Total	649(100)			1784(100)			2433(100)
Depth							
Level A	56(8.7)	0.271	0.000	1110 [#] (62.2)	0.705	0.000	1166 (47.9)
Level B	86 (13.2)	0.346	0.000	232(13.1)	0.324	0.000	318(13.1)
Level C	507 [#] (78.1)	0.816	0.000	442 (24.8)	0.434	0.000	949(39)
Total	649(100)			1784(100)			2433(100)
Width							
Class I				1112 [#] (62.4)	0.704	0.000	1112 (62.4)
Class II				240 (13.5)	0.330	0.000	240 (13.5)
Class III				432 (24.1)	0.430	0.000	432 (24.1)
Total				1784(100)			1784(100)

[#]High association

^a= Pearson Chi-Square for correlation between pattern and jaw

Discussion

This study aimed to evaluate the prevalence and pattern of third molar impaction from a large number (5923) of subjects based on digital panoramic

radiographs using a proposed modified method adapted from existing literatures. In the last four decades, panoramic radiograph (OPG) acquired popularity as a tool for diagnosis, screening, and pre-surgical planning for third molar impaction. OPG

is a reputable tool for assessing angular positions, impactions, eruption status, and the relationship between third molars and inferior alveolar canal.^{43,45} Another widely used method for impaction diagnosis is the peri-apical (PA) radiograph, which provides lower doses of radiation, less magnification, and an accurate relationship between the bone height and teeth.⁴⁶ However, the mandibular canal could not be identified clearly on PA radiographs, or it displays part of a mandibular canal or portion of soft and hard tissue in the third molar region, which is a major source of concern. A panoramic radiograph allows maxilla and mandible to be viewed into a single image. It is economical and exposed minimal radiation.⁴⁷ High distortion, a two-dimensional (2D) perspective, and reduced image quality are drawbacks of this technique. Whereas cone Beam Computed Tomography (CBCT) technology intensifies this phenomenon with a progressive three-dimensional (3D) image quality view of mandible and its associated anatomical structure. Studies revealed that CBCT influences optimal risk assessment, and consequently, aids adequate surgical planning.⁴⁸ Despite this, clinicians still be devoted to OPG since CBCT imaging exposes patients to higher radiation doses as well as extravagant spending.⁴⁷

Previous studies have suggested that third molar eruption completes between 17 to 20 years of age.^{11,49} Hence, 19 years old was selected as the minimal age for inclusion criteria. It is essential to highlight that the maxilla and mandibular growth continue until age of 17.⁴⁹ This introduces a possible implies that at the age of 19, it can reveal whether a third molar is erupting normally, or it remains partially erupted or unerupted. According to Quek et al.¹² the most appropriate age for investigating the prevalence and pattern of third molar impaction is between 18 to 25 years old.

The prevalence of third molar impaction recorded in this study was 46.2%. This result is substantially higher than the global average rate of third molar impaction of 24.40%,² while it is within the range of worldwide prevalence of third molar impaction (7.5% to 73.5%).^{4,5} Racial variation, dietary habit, masticatory function, and genetic factors all have an impact on jaw size, tooth size, and facial growth; therefore, the different studies provide different third

molar prevalence data which is diverse and depends on the assessment method. The racial diversity in prevalence of third molar impaction described in literature is depicted by the choropleth of the global map (Figure 1). Compared to the global race, the East Asian and Southeast Asian people have a greater prevalence of third molar impaction. In comparison to Africans and Americans, East Asian communities prefer a soft diet consisting of steamed rice cake, steamed buns, nodules, dumplings, sushi, and veggies.⁵⁰ An experimental investigation found that consumption of soft diet offers reduced masticatory activity on the mandible resulting in morphological remodelling of the mandible, such as reduce alveolar bone size.⁵¹ In consonance with Yamada and Kimmel⁵², craniofacial growth has a direct relationship with dietary habit and masticatory function, specially affecting the mandible, which may influence third molar impaction. The growth pattern of ramus of the mandible is related to resorption of its anterior surface and deposition of its posterior surface. Regardless of whether this process is in disequilibrium or not, the mandibular third molars will typically do not have enough space to erupt.⁵² Appropriate eruption of third molars also depends on their congenial path of eruption. In an example, the path of eruption will be uncongenial if the third molar tooth bud is angulated mesially during the primary stage of calcification and root development.

In line with previous studies, this study found third molar impaction had a significant greater predilection on mandible than maxilla. This finding is in accordance with the findings of many previous studies.^{9-13,24,37,39} In contrast, study found that maxillary third molar is more likely to be impacted than the mandibular third molar⁷ whereas others found no significant differences between the jaws.^{25,32} However, it has been acknowledged that there is substantial debate among researchers because the incidence of maxillary to mandibular impaction is much more variable in African and Asian races than North America, European or Arabian.² The uneven resorption and deposition process at the mandibular ramus angle may explain the greater frequency of third molar impaction in the mandible. This factor turns out into a decrease in mandibular angulation and an

increase in mandibular plane angulation, supporting the argument of the aetiology of mandibular third molar impaction.⁴⁶

It is interesting to note that neither gender nor population were statistically significant in terms of the prevalence and pattern of third molar impaction in this study. Despite the fact females supposed to have a higher risk of impaction than males, surprisingly, most of the studies concur with the findings of this current study.^{25,32,34} Nevertheless, a different observation was made by Kruger et al.⁶ and Yuasa and Sugiura⁸ where females have higher frequency of third molar impaction.

Similarly, this study found the frequency of third molar impaction in order to side was mandibular right > mandibular left > maxillary right > maxillary left, which is in agreement with Quek et al.¹². In addition, the present study found no significant differences between the right and left side of the jaw and these disparities are in accordance with Hatem et al.⁵³

It is difficult to compare the prevalence of different angulation of third molar impaction, as examination methods vary in different studies. Since the lack of precision in visual impression or protractor,²⁰ the current study investigated the angular position using a digital software measurement technology, Planmeca Romexis® 3.0 software, for the first time to avoid errors. The mesioangular (32.8%) impaction was the most prevalent angular position exhibited in this study, followed by horizontal (24.2%), vertical (23.4%), distoangular (15%), and others (4.6%). The arch and the angular position of third molar impaction were found to have a significant association. Mesioangular (36.55%, $p < 0.001$) impaction was significantly higher in the mandibular arch while distoangular (55.9%, $p < 0.001$) impaction was significantly higher in the maxillary arch. In most of the earlier investigations, a similar finding was recorded in the mandibular arch,^{7,9,10,12,13,24,32,39,53} however, for the maxillary arch, this unique finding contradicts with literature documented previously. Vertical impaction is the most frequent pattern in the maxillary arch.^{7,9,10,12,13,24,32,39,53}

The level of third molar impaction exhibits the depth of impaction in relation to bone and estimates third molar's height compared to the adjacent second

molar. Strong significant evidence was found between the level of eruption and arch. Level A (62.2%, $p < 0.001$) was most common in mandibular arch and Level C (78.1%, $p < 0.001$) was most common in maxillary arch. The findings are also supported by earlier trials.^{7,12,14} Finally, assessment of the width of impaction correlates with the anterior border of ramus; thus, the width of maxillary arch was not recorded in this present study. Class I has been followed by Class III and Class II was the most common width pattern of mandibular third molar impaction.

Extraction or surgical intervention is indicated when the third molar is associated with pathological conditions such as periodontitis, pericoronitis, pulpitis, cystic lesion, or root resorption⁴⁶. The surgical procedure may correlate complications during surgery as well as post-operative surgery, for example- nerve injuries, dry socket, hemorrhage, oroantral perforation, or fracture of mandible.⁴⁶ The hazard of surgery is accompanied by the depth and width of the impacted third molar. Besides, the risk of nerve injury in the mandible is highest in horizontal impaction, followed by distoangular, mesioangular, and vertical impaction.^{48,54} Moreover, oroantral perforation is the most common operative complication during maxillary third molar extraction.⁵⁵ The incidence of oroantral perforation increases with the depth of maxillary impaction.⁵⁵ Therefore, meticulous investigation and planning prior to clinical procedures minimize the risk factors during and post-operative surgery.

A prosperous surgical extraction protocol for third molars is dependent on three key factors: precise diagnosis, flap design and extraction technique. An unerring flap design improves healing and reduces the post-operative pain and swelling. Sandhu et al.⁵⁶ reported, the grade of impaction level and angulation increase post-operative inflammation. A significant association was identified between angulation and type of flap design; higher post-operative inflammation was noted in vertical molars compared to mesioangular in terms of envelop flap design.⁵⁶ Bataneh and Batarseh⁵⁷ exposed triangular flap or modified triangular flaps result in decreased post-operative complications than the envelope flap design. Moreover, injury to the inferior alveolar

nerve, lingual nerve, or fracture of the mandible increased with the increased depth and width of the impaction. Sectioning of crown or coronectomy is indicated when there is a risk of nerve injury though; it is known that it might prolong post-operative healing and may associate with secondary consequences such as pain and swelling.⁴⁸ Considering all these major considerations, a comprehensive surgical protocol based on clinical investigations and demographic variations of third molar impaction will need to be advised in near future.

Conclusion

As far as to our knowledge, this is the first study reporting the third molar impaction using the digital software measuring medium in identifying the third molar impaction prevalence and patterns. The use of digital medium also enhanced investigations for

obtaining precise outcomes. The outcomes reported in this current study would be revealing some predictability of third molar impaction in some extent. Understanding the distribution of third molar impaction frequencies is a primary step for reviewing and suggesting appropriate treatment protocol.

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Conflicts of Interests Statement: The authors declare that they have no conflicts of interest

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