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The influence of arch shape on the incidence of third molar impaction: A cross-sectional study

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ABSTRACT

Introduction: Impaction of third molar is a pathological problem that reduces the chance of normal eruption of tooth. The main reason for impaction is inadequate space in the maxillary and mandibular arch. The aim of this study is to investigate the relationship between arch shape and the prevalence of third molar impaction.
Methods: This cross-sectional study was performed on patients referring to the Department of Oral and Maxillofacial Surgery between December 2023 and February 2024 to obtain an orthopantomogram (OPG). Convenience sampling was employed, and orthopantomograms were analyzed to determine impaction types. Dental arch shape variables were assessed using Budiman's analysis, with a Chi-square test employed to evaluate any significant association between arch shape and impaction type at a significance level of 0.05.
Results: Among the 185 maxilla and 185 mandibles studied, 154 were male patients, and 216 were female patients, with a mean age of 26.75 years. A statistically significant difference was found in impacted teeth, among females having more impacted molars than males (p-value = 0.002*). However, no significant differences were found in the type of impaction, Gregory classification, or position based on the shape of the mandible on both the right and left sides (p-value > 0.05). Similarly, no significant differences were observed in Gregory's classification based on the shape of the maxilla on both the right and left sides. However, there is a statistically significant difference in the occurrence impaction based on the maxilla's shape (p-value < 0.05).
Conclusion: The study suggests a significant correlation between maxillary arch shape and the occurrence of third molar impaction, with a higher prevalence among females.

1. Introduction

Impaction of the tooth is a pathological problem resulting in the malfunctioning of the tooth, where a tooth cannot erupt in normal occlusion. The main reason for impaction is inadequate space in the maxillary and mandibular arch supporting the tooth's eruption (Ahmad et al., 2021). Some other reasons mentioned in the literature are genetic disorders and tooth malformation (Ahmad et al., 2021). Disimpaction surgeries are performed to overcome this problem. Literature suggests that 68 % of impaction cases are related to the mandibular third molar (Alfadil & Almajed, 2020; BASHIR et al., 2016). Studies have shown an increasing prevalence of mandibular impaction from 20 % to 70 % (Alfadil & Almajed, 2020; BASHIR et al., 2016). Most studies have not indicated the prevalence of gender (Hasan et al., 2021; Hashemipour et al., 2013; Hassan, 2010). However, limited research studies have demonstrated that mandibular third molar impaction is more common among females than males.

Studies have shown various pathological conditions associated with impacted third molars, like pericoronitis, root resorption, cystic lesions, periodontitis, neoplasm, and malocclusions (Ahmad et al., 2021; Batwa,

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2018; Hassan, 2010). Additionally, studies have reported that the impacted third molar of the mandible weakens its angle, making it vulnerable to fracture (Ahmad et al., 2021; Batwa, 2018; Hassan, 2010). Moreover, temporomandibular pain and neuralgia are also associated with impacted third molar.

Several methods have been utilized to classify the third molar impaction (Vranckx et al., 2021). The Pell and Gregory classification system is most used in clinics and research to check the level of impacted third molar with the adjacent tooth (Idris et al., 2021; Kaomongkolgit & Tantanapornkul, 2017; Khouri et al., 2022). These classifications are based on factors such as the level of impaction, angulation of the third molar, and the relationship of the third molar with the anterior border of the ramus of the mandible. The depth or level of the maxillary and mandibular impacted third molar is classified by Pell and Gregory's classification, where the impacted third molar is classified according to the level of occlusion of the adjacent second molar (Idris et al., 2021; Kaomongkolgit & Tantanapornkul, 2017; Khouri et al., 2022). Winter's classification is used to evaluate the angulation of an impacted molar (Riedel, 1960; Tassoker et al., 2019). This entails measuring the angle produced between the longitudinal axis of the second and third molars. Research has conducted measurements on the curvature of arches, malocclusion, and their correlation with impacted molars. These studies have found that square and oval-shaped arches have a higher incidence of impacted teeth than U-shaped arches (Riedel, 1960; Tassoker et al., 2019).

In the existing literature there is no consistent estimate on incidence of third molar impaction and the estimated value ranges between 3 % to 55 % (Abdelkarim, 2019; Ahmad et al., 2021). A study on the Iranian population found that the incidence of mandibular third molar impaction is higher in females (Hashemipour et al., 2013). On contrary, studies on Indian and American cohort found higher prevalence of mesio angular impaction of third molar in males (Ocak et al., 2023; Passi et al., 2019). Another survey of adults from Oman revealed that out of 1000 observed oral panoramic radiographs (OPGs), almost 50 % exhibited some form of impacted third molar (Yilmaz et al., 2016). Various studies in different regions of Saudi Arabia have recorded the frequency of third molar impaction. In 1986, Haidar and Shalhoub (Haidar & Shalhoub, 1986) surveyed 1000 patients from the Central part of the kingdom to determine the prevalence of impacted third molars. A prevalence rate of 32.3 % was recorded. Alfadil and Almajed (Ahmad et al., 2021; Alfadil & Almajed, 2020) recently stated that the prevalence rate in the Central part of the kingdom is 58.3 %. Hassan (Hasan et al., 2021) found a prevalence rate of 40.6 % in the Western region, while Syed et al. (Syed et al., 2017) reported a prevalence of 18.76 % in Asir province, which is in the Southern region. Only one study has been conducted in Jazan region, focusing on the prevalence of impacted molars based on various classifications (Idris et al., 2021). All these studies that have been cited have used the method that have under or over-estimated the population rates and should be treated with skepticism. However, no study has reported the prevalence of impacted third molar according to the shape of the arch. Hence, this study aims to investigate the relationship between the shape of the arch and the incidence of impaction of the third molar using Orthopantomography (OPGs) in the population of the Jazan region. The null hypothesis stated that there is no significant association with the prevalence of third molar impaction, the shape of the arch, and its variables (age, gender, type of impaction, and angulation).

2. Material and method

This cross-sectional was performed at the Department of Oral and Maxillofacial Surgery at the School of Dentistry, Jazan University, KSA. The study protocol was made according to the declaration of Helsinki (revised version 2017) and was approved by the ethical committee of the College of Dentistry, Jazan University (Ref. No. REC-45/07/933). The study's objective was explained to the patients, and informed consent was obtained.

2.1. Study participants

To identify the pattern of maxillary and mandibular third molar impaction, a cross-sectional study was implemented with the patients referred to the Department of Oral and Maxillofacial Surgery for treatment. The orthopantomograms were obtained from the patients from July 2023 to October 2023. A defined inclusion criterion was patients above 18 years of age, with no missing teeth, and ongoing orthodontic treatment.

The patients were excluded if they were under 18 years of age, had any oral pathologies, had any trauma to the jaws, had any craniofacial anomalies, or the patient had undergone the extraction of a third molar. Rao soft sample size calculator calculated the sample size. The estimated sample size of 280 OPGs was calculated to achieve the confidence interval of 95 % and marginal error of 5 %. The calculation was based on the number of patients visiting the oral and maxillofacial department between the three months which ranged between 300 and 500. The final sample size of 360 OPGs was considered to increase sample power.

2.2. Study variables

Age and gender were recorded as demographic variables. Two calibrated dental surgeons examined the OPGs of the participants independently in the darkroom on an X-ray viewer. An inter-examiner error was calculated, and in case of any disagreement, a third surgeon and a radiologist were contacted for a final decision. The examiner evaluated a total of three hundred seventy radiographs, and to evaluate re-examiner reliability, a total of one hundred eighty-five radiographs were considered. Additionally, to confirm the findings, a radiologist performed a clinical examination. The final variables for each were recorded based on the OPGs, impaction type, and arch shape.

2.3. Shape of arch and impaction

The shape of the arch was evaluated by the clinical examination and is classified into three parts: oval, square, and taper. The arch form was evaluated using Budiman's analysis, which considered intra-oral measurements such as inter-canine width (ICW), canine depth (CD), intermolar width (IMW), and molar depth (MD). Clinical measurements were taken for all patients with the help of a measuring scale and evaluated with the help of Budiman formula.

$$ArchformIndexformula = \frac{CD}{ICW} \times \frac{IMW}{MD}$$

If the ratio is < 45.30 %, means square arch form; ratio in between 45.30 and 53.37 %, means oval arch form; and ratio more than 53.37 %, means tapered arch form. To consider an impacted third molar, the molar should not have a functional occlusion, and root formation should be completed.

2.4. Depth of impaction

The depth of impaction was classified according to Pell and Gregory's classification. According to this classification, the relation of the cementoenamel junction of the third molar with the alveolar ridge is divided into three levels, where at level 1, the molar is above the alveolar bone but does not follow functional occlusion; at level 2, partially impacted, at level 3: completely impacted (Fig. 1A). According to the position of the third molar, the Pell and Gregory classification mentions the relation of the third molar with the anterior border of the ramus and is categorized as class I: anterior to the anterior border of the ramus; class II: half of the crown is covered by the anterior border of the ramus; class III: the crown is fully covered by the anterior border of the ramus (Fig. 1B).

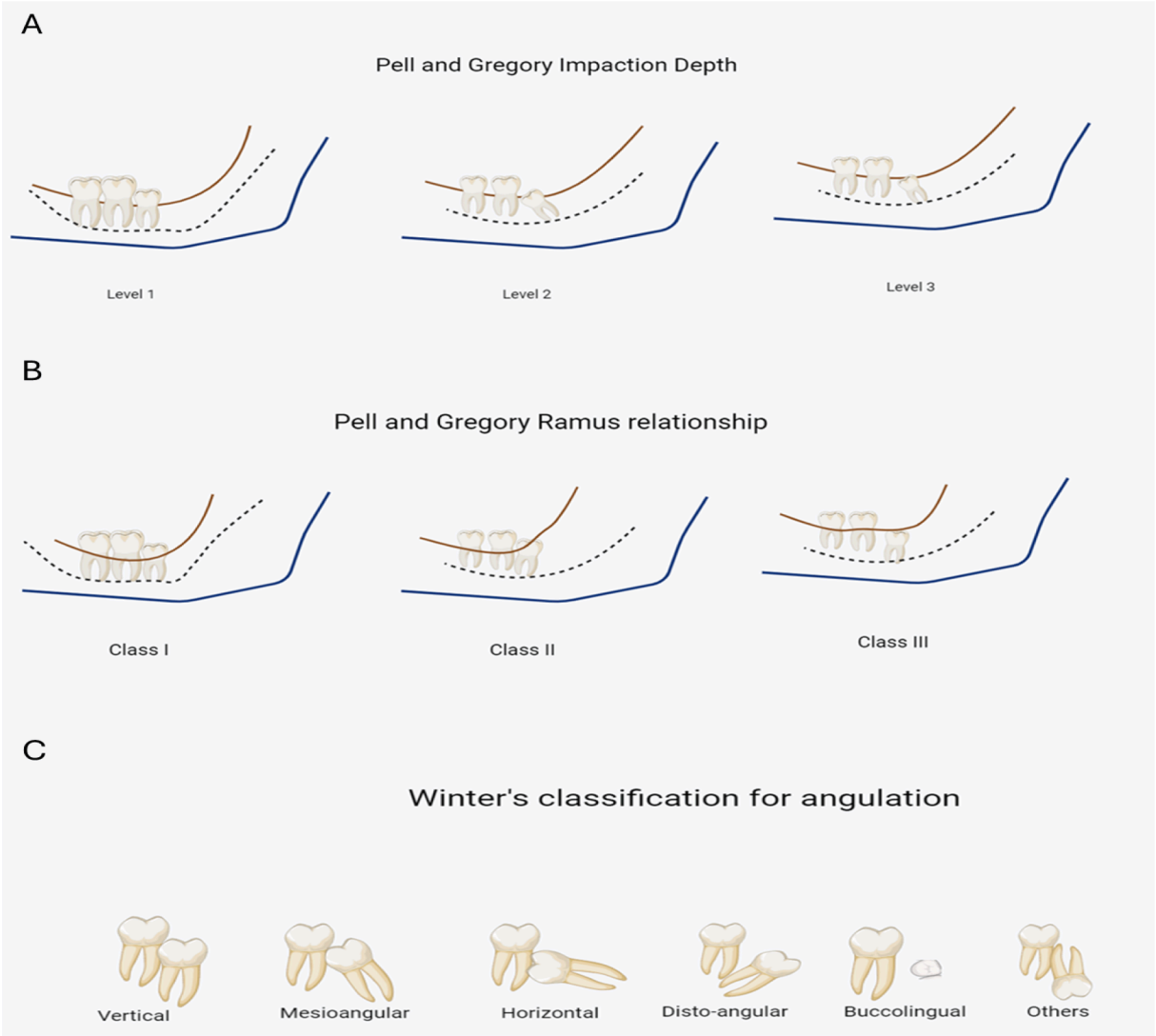

Fig. 1. A) Pell and Gregory's classification of ramus relation; B) Pell and Gregory Ramus Relationship; C) Winter's classification for angulation.

2.5. Type of impaction (angulation)

Winter's classification was utilized to evaluate the angle between the longitudinal axis of the maxillary and mandibular second and third molar. This relation was measured by an orthodontic protractor and is categorized as mesio angular impaction (11–79), Distoangular impaction (−11 to −79), vertical (10 to −10), and horizontal (80 to 100). According to Winters, buccolingual impaction is when the crown and roots are superimposed (Fig. 1C).

2.6. Statistical analysis

The age and gender variables were calculated using descriptive statistics (mean and standard deviation). The patient's age, gender, number of impacted third molars, impaction classification, and impaction level have been demonstrated by frequency and percentage. Additionally, a chi-square test was performed using the Statistical package for social sciences (SPSS version 22.0, IBM, Chicago, USA) to analyze the statistical values. The p-value was set at 0.05, at the confidence interval of 95 %. The inter-examiner reproducibility to diagnose the impaction at a specified period was 94 %, and the intra-examiner reliability was measured at 88.5 % for all impactions.

3. Results

This study included 185 participants, with 96 (67.7 %) females and 89 (32.9 %) males. The average age of the participants was 26.83, and there was no statistically significant difference in age between males and females (p-value = 0.36). The study, 370 total participants were analyzed, with 185 in the maxillary OPGs and 185 in the mandibular OPGs. It was found that 268 cases had at least one impacted molar, as shown in Table 1.

In the Oval mandible category, 15 females and 13 males indicate a relatively balanced distribution between genders (Table 2). Conversely, the square mandible category shows a notable difference in counts, with 23 females compared to 47 males, suggesting a higher prevalence of

Table 1
Distribution of subjects based on age and shape of arch.

Shape	Mandible			Maxilla		
	N	Mean age	Std. Deviation	N	Mean age	Std. Deviation
Oval	28	27.00	7.77	50	26.56	10.28
Square	70	26.41	9.47	53	27.64	9.73
Taper	87	27.09	10.02	82	26.45	8.84
Total	185	26.82	9.46	185	26.82	9.46

Table 2
Distribution of subjects based on gender and shape of arch.

Shape	Mandible			Maxilla		
	F	M	Total	F	M	Total
Oval	15	13	28	20	30	50
Square	23	47	70	17	36	53
Taper	58	29	87	59	23	82
p-value	0.001*			0.001*		

Square-shaped mandibles among males. Interestingly, the Taper mandible category exhibits a contrasting trend, with 58 females and 29 males, indicating a higher prevalence of Taper-shaped mandibles among females (Table 2).

In the Oval maxilla category, there are 15 females and 20 males, indicating a slightly higher prevalence of Oval-shaped maxilla among males. The Square maxilla category exhibits a different trend, with 23 females and 17 males, suggesting a higher prevalence of Square-shaped maxilla among females. The Taper maxilla category has 58 females and 59 males, showing a relatively balanced distribution between genders (Table 2)—a p-value of 0.001 statistical significance of gender differences within each shape category.

Table 3 show a notable difference between the number of females and males with impacted teeth compared to those without impacted teeth. Specifically, there are 73 females and 59 males with impacted teeth, while 23 females and 30 males without impacted teeth. This difference is statistically significant, with a p-value of 0.002*, specifically in the mandibular right side. There is a consistent pattern seen in the left side of the mandible (0.049), as well as the right (0.042) and left (0.049) sides of the maxilla. This pattern is statistically significant with a p-value of less than 0.05, respectively.

Table 4 demonstrates that there is no statistically significant difference in Gregory's classification of impaction and position based on the shape of the mandible on both the right and left sides (p-value > 0.05). However, statistical significance was recorded among the types of impactions in the mandible on the right side (p-value $= 0.01$).

Table 5 illustrates no statistically significant difference in Gregory's impaction classification based on the maxilla's shape on both the right and left sides. There was no statistically significant difference in the type of impaction based on the shape of the maxilla on the left side. However, there was a statistically significant difference in the type of impaction based on the shape of the maxilla on the right side (p-value < 0.05).

4. Discussion

The present study is the first to evaluate the frequency of impacted third molars, the shape of the dental arch, and multiple variables such as age, gender, type of impaction, and angulation. The result of this study highlights the need to study the relationship between the shape of the arch and the prevalence rate. The extraction of impacted third molars has been found to enhance the quality of life for young adults significantly. Research indicates a strong correlation between advancing age and the likelihood of experiencing complications after undergoing disimpaction surgery (Hounsome et al., 2020). Facial types and arch shapes are closely linked to impaction, making them a valuable tool for predicting the specific type of impaction.

Published literature confirms that mandibular third molars fail to erupt primarily due to the limited space within the alveolar arch between the distal aspect of the second molar and the ascending mandibular ramus (Husain & Rengalakshmi, 2021; Idris et al., 2021; Jaroń & Trybek, 2021). The growth and development of the mandible are related to various factors and are frequently associated with the need for sufficient space to ensure the correct alignment of the mandibular third molar (Hassan, 2011; Hounsome et al., 2020). Several skeletal factors have been identified as playing a role in reducing the space needed for the eruption of the third molar. These factors include the measurement of mandibular length from the gonion to the condylar head, the vertical orientation of condylar development, and the retrograde eruption pattern of the dentition (Hashemipour et al., 2013; Jena et al., 2022; Kaomongkolgit & Tantanapornkul, 2017; Khouri et al., 2022). Extracting adjacent teeth, like the second molar and premolar, is sometimes necessary in managing impacted third molars. This is done as part of an orthodontic intervention to address the third molar impaction and this step considers various factors that contribute to the development of the mandible. These factors include the extent, quantity, and direction of mandibular growth, the structural remodelling and length of the mandibular ramus, the timing of third molar maturation, the alignment of posterior dentition, and the proportional relationship between dentition and jaw size (Hounsome et al., 2020; Husain & Rengalakshmi, 2021). In addition, genetic involvement and dietary habits are also reasons associated with third molar impaction.

In this current study, the prevalence of mandibular third molar impaction was 55.5 %, while maxillary third molar impaction was 40.4 %, respectively. These findings are like those of Alfadil et al. (Alfadil & Almajed, 2020) (58.5 % and 41.5 %) and Hassan (Hassan, 2011) (53.1 % and 31.8 %). In our study, a statistical correlation was reported between the incidence of impaction and gender, which was not reported in the survey by Alfadil et al. (Alfadil & Almajed, 2020) and Hassan (Hassan, 2011). Nevertheless, contrasting results have been noted, with some studies indicating a higher incidence of third molar impaction in males (Husain & Rengalakshmi, 2021; Idris et al., 2021; Jaroń & Trybek, 2021). This could be attributed to the growth pattern of the mandible, where the growth of the male jaw persists till 20 years, and female jaw growth ceases at 18 years before the eruption of the third molar. Hence, the space for the eruption of the third molar is reduced.

Regarding arch shapes, oval shapes, tapered shapes, and square-shaped arches were considered. It was found that males have more square-shaped mandibular arches, and females have an oval-shaped arches with a statistically significant relation. Furthermore, orthodontic studies on arch shapes suggest that males have more square mandibular arches than females (Chen et al., 2020; Hassan, 2010; Jena et al., 2022). Only the shape of the right side of the maxillary arch demonstrated a significant association with the third molar impaction (p-value $= 0.03$). To the author's knowledge, this is the first study to examine this correlation.

Regarding mandibular impaction, the assessment was based on the type of impaction; the tapered-shaped mandible had a maximum of horizontally impacted molar, which was found to be statistically significant (p-value $= 0.01$). According to the Pell and Gregory classification, class II was prominent in oval-shaped mandibles. This finding is like other studies among the Saudi Arabian population, where level B was prevalent in impacted mandibular molar (Tassoker et al., 2019;

Table 3
Distribution of subjects impacted third molar tooth (teeth) based on gender, side of impaction and arch.

Arch	Side	Female		Male		p-value
		With Impacted tooth	Without impacted tooth	With Impacted tooth	Without impacted tooth	
Mandible	Right	73	23	59	30	0.002*
	Left	71	25	63	26	0.049*
Maxilla	Right	79	17	61	28	0.041*
	Left	75	21	62	27	0.049*

Table 4
The distribution of impacted mandibular third molars according to variables.

Mandibular molar			Right			Total	Left			Total
			Oval	Square	Taper		Oval	Square	Taper	
Type of impaction (Winter Classification)	Distoangular	Frequency	1	4	2	7	2	6	4	12
		%	14.3	57.1	28.6	100.0	16.7	50.0	33.3	100.0
	Horizontal	Frequency	0	1	2	3	0	2	0	2
		%	0.0	33.3	66.7	100.0	0.0	100.0	0.0	100.0
	Mesioangular	Frequency	4	9	14	27	5	12	11	28
		%	14.8	33.3	51.9	100.0	17.9	42.9	39.3	100.0
	Vertical	Frequency	14	27	45	86	13	27	45	85
		%	16.3	31.4	52.3	100.0	15.3	31.8	52.9	100.0
p-value			0.01*				0.61			
Pell and Gregory's classification	class I	Frequency	8	17	29	54	8	25	26	59
		%	14.8	31.5	53.7	100.0	13.6	42.4	44.1	100.0
	class II	Frequency	10	21	33	64	12	20	32	64
		%	15.6	32.8	51.6	100.0	18.8	31.3	50.0	100.0
	Class III	Frequency	1	2	0	3	0	1	1	2
		%	33.3	66.7	0.0	100.0	0.0	50.0	50.0	100.0
p-value			0.38				0.88			
Pell and Gregory classification (Position)	Position A	Frequency	10	18	33	61	12	20	28	60
		%	16.4	29.5	54.1	100.0	20.0	33.3	46.7	100.0
	Position B	Frequency	8	18	19	45	8	21	23	52
		%	17.8	40.0	42.2	100.0	15.4	40.4	44.2	100.0
	Position C	Frequency	1	4	10	15	0	5	8	13
		%	6.7	26.7	66.7	100.0	0.0	38.5	61.5	100.0
p-value			0.36				0.73			

Table 5
The distribution of impacted maxillary third molars according to variables.

Maxilla			Right			Total	Left			Total
			Oval	Square	Taper		Oval	Square	Taper	
Pell and Gregory's classification	Type A	Frequency	13	18	28	59	12	19	24	55
		%	22.0 %	30.5 %	47.5 %	100.0	21.8 %	34.5 %	43.6 %	100.0
	Type B	Frequency	16	8	21	45	12	8	23	43
		%	35.6 %	17.8 %	46.7 %	100.0	27.9 %	18.6 %	53.5 %	100.0
	Type C	Frequency	9	4	12	25	13	7	13	33
		%	36.0 %	16.0 %	48.0 %	100.0	39.4 %	21.2 %	39.4 %	100.0
p-value			0.13				0.08			
Type of impaction (Winter's classification)	Distoangular	Frequency	8	3	15	26	11	4	13	28
		%	30.8 %	11.5 %	57.7 %	100.0	39.3 %	14.3 %	46.4 %	100.0
	Mesioangular	Frequency	3	0	3	6	3	1	3	7
		%	50.0 %	0.0 %	50.0 %	100.0	42.9 %	14.3 %	42.9 %	100.0
	Vertical	Frequency	29	27	43	99	25	29	44	98
		%	29.3 %	27.3 %	43.4 %	100.0	25.5 %	29.6 %	44.9 %	100.0
p-value			0.04*				0.10			

Vranckx et al., 2021; Yilmaz et al., 2016). However, this conflicts with other studies where class III or class I is predominant. Hassan AH surveyed to assess the pattern and frequency of the third molar concerning the ramus and demonstrated that Class I is the highest in frequency and percentages (Hassan, 2011). These differences could be attributed to variations in sample selection and analysis criteria.

Additionally, over 66 % of mandibular third molar impactions were of the mesioangular type, consistent with the findings of other studies where mesioangular impaction was predominant (Kindler et al., 2019; Li et al., 2021; Ocak et al., 2023). The Chi-square test revealed a notable increase in the incidence of mesioangular impactions in the square-shaped and tapered arch; however, these findings were insignificant. According to our findings, the prevalence of mandibular third molar impaction was higher in individuals with a tapered-shaped maxillary and square-shaped mandibular arch type than those with an oval shape; however, the results were not statistically significant. Hasan et al. found that short mandibles are more susceptible to third molar impaction (Hassan, 2010). The presence of a lengthy, upwardly inclined ramus and a comparatively shorter mandibular length are indicative of mandibular third molar impaction.

The result of this study suggests that the individuals with square-shaped mandible and tapered-shaped maxilla had increased chances of maxillary and mandibular third molar impaction compared to oval-shaped arches. However, no statistical significance was reported due to the limited sample size (n = 370). Further investigations are required to assess the incidence of impacted molar and its association with the shape of an arch among larger populations to support the findings of this study. Moreover, further prospective studies are needed to enhance the understanding of dental surgeons on the third molar impaction, as these teeth have the potential to change their position and continue erupting from their current location. These studies would allow for monitoring potential changes in the inclination of third molars and further validate the shape of the arch as a predictive tool of third molar impaction.

5. Conclusion

The result of this study suggests a significant correlation between maxillary arch shape and the occurrence of third molar impaction, with a higher prevalence among females. Other parameters were also significant among the genders. In the mandibular and maxillary arch, vertical impacted angulation was more prevalent. However, mandible level 1 was most prevalent, and maxilla level 3 was prevalent. Class II impaction in relation to the anterior border of the mandible was most common among the genders on both sides, with oval and square-shaped

arches.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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