Association between Impacted Maxillary Canine and Peg-Shaped Maxillary Lateral Incisors

Mahfud F Mohamed
Faculty of Dentistry- University of Benghazi
mahfud.alaty@uob.edu.ly

Abstract:

This study aimed to investigate the prevalence of maxillary canine impaction in association with peg-shaped maxillary lateral incisors (PSMLI). ***Methods****: Pretreatment orthodontic records of Libyan orthodontic patients were screened in the Department of Orthodontics, Faculty of Dentistry, University of Benghazi, and three private orthodontic43clinics in the city. Records of 2650 patients (1907 females and 743 males) were investigated; patients' ages ranged from 11 to 38 years old. The documents, dental and medical history, study models, and OPG, were checked by the researchers investigating the association between the occurrence of PSMLI occurrence of impaction of the maxillary canine(s). SPSS (IBM® SPSS® Statistics) version 27 was used for descriptive statistics (frequencies, mean, SD, etc.), the inferential statistics (prevalence, association, and statistical significance), and for intra-examiner reliability testing.* **Results**: IMC was found in 368 cases (13.9%). there were 289 (10.9 %) and 269 (10.2 %) right-sided and left-sided PSMLI, respectively. There were 50 right-sided and 30 left-sided PSMLI. The total of bilateral PSMLI was 239 (9 %). Chi-Square test and Odds-Ratio calculations revealed no association between IMC and right-sided and left-sided PSMLI (**P > 0.05**). The association between unilateral and bilateral PSMLI is statistically significant (**P < 0.05**). **Conclusion**: The prevalence of impacted permanent maxillary canines (IMC) is not associated with the prevalence of PSMLI, and the presence of PSMLI is not the only risk factor for impaction of the permanent maxillary canine. Bilateral PSMLI is more prevalent than unilateral PSMLI.

Key words*: Maxillary canine impaction, Peg-shaped maxillary lateral incisors, dental anomalies*

الملخص

هدفت هذه الدراسة إلى استقصاء انتشار انحصار الضرس القاطع العلوي (IMC) فيما يتعلق بالقواطع الجانبية العلوية ذات الشكل القرني(PSMLI)

الطرق: تم فحص سجلات مرضى تقويم الأسنان الليبيين قبل العلاج في قسم تقويم الأسنان، كلية طب الأسنان، جامعة بنغازي، وثلاث عيادات خاصة لتقويم الأسنان في المدينة. تم التحقيق في سجلات 2650 مريضًا (1907 إناث و743 ذكور)، تراوحت أعمار المرضى من 11 إلى 38 عامًا. تم التحقق من الوثائق، التاريخ الطبي والأسنان، نماذج الدراسة، وصور الأشعة المقطعية (OPG)من قبل الباحثين الذين يحققون في العلاقة بين وقوع PSMLI وحدوث انحصار الضرس القاطع العلوي. تم استخدام برنامج (IBM® SPSS® Statistics) SPSS النسخة 27 لإحصائيات الوصف (التكرارات، المتوسط، الانحراف المعياري، إلخ)، والإحصائيات الاستنتاجية (الانتشار، العلاقة، والأهمية الإحصائية)، واختبار موثوقية الفاحص الداخلي.

النتائج: تم العثور على IMC في 368 حالة (13.9%). كانت هناك 289 (10.9%) من حالات PSMLI في الجهة اليمنى و269 (10.2%) في الجهة اليسرى على التوالي. كان هناك 50 حالة PSMLI في الجانب الأيمن و30 حالة في الجانب الأيسر. كان مجموع حالات PSMLI الثنائية 239 (9%). أظهر اختبار الاختبار الاحصائي(Chi-square test) وحسابات نسبة الأرجحية Odds ratio)) عدم وجود علاقة بين IMC و PSMLIفي الجانبين الأيمن والأيسر .($P > 0.05$) العلاقة بين PSMLI وحيدة الجانب والثنائية كانت ذات دلالة إحصائية.($P < 0.05$)

الخلاصة: ليس هناك ارتباط بين انتشار انحصار الضروس القاطعة العلوية الدائمة (IMC) وانتشار PSMLI ، ووجود PSMLI ليس العامل الوحيد الذي يزيد من خطر حدوث انحصار الضرس القاطع العلوي الدائم. كما أن PSMLI الثنائية أكثر انتشارًا من PSMLI وحيدة الجانب.

Introduction:

The permanent maxillary canine impaction is a developmental aberration which stimulates the attention of dentists, particularly orthodontists. The prevalence of maxillary canine impaction rages from 0.6% to 1%, and it comes the second most frequent impacted tooth After third molars(Afify & Zawawi, 2012; Herrera-Atoche et al., 2017; Lövgren, Dahl, Uribe, Ransjö, & Westerlund, 2019; Sambataro, Baccetti, Franchi, & Antonini, 2005). Apart from inspected causes such as cleft palate, trauma, pathological factors (cyst/tumor), and root dilacerations, the etiology of maxillary canine impaction has not been fully clarified yet.

There is a variety of etiological factors have been suspected including genetic causes, long path of eruption, and lack of space,(Becker, Chaushu, & Orthopedics, 2015; S. Peck, Peck, & Kataja, 1994; Russell & McLeod, 2008; Stellzig, Basdra, & Komposch, 1994). Nevertheless, two theories have been proposed to explain the etiology of the maxillary canine impaction.

Firstly, the guidance theory, which explains the maxillary canine impaction by the absence of the guide which is used by the canine to erupt in its normal place. The guide is the distal aspect of the permanent maxillary lateral incisors. Loss of guidance is seen in cases of agenesis of maxillary lateral incisors or root malformation. In such case, according to the guidance theory absent or insufficient guiding root of the maxillary lateral incisor makes canine unable to follow the proper pathway to the its normal anatomical position(Becker et al., 2015; Y. Kim, Hyun, & Jang, 2017; Papageorgiou, Seehra, Cobourne, Kanavakis, & research, 2025; S. J. A. J. o. O. Peck & Orthopedics, 2016).

Secondly, the genetic theory explains the impaction of maxillary canines by genetic influences. The theory bases on several observations including the increased frequency of maxillary canines in some family but not others and association of impacted canines with various genetic dental anomalies(Baccetti, Mucedero, Leonardi, Cozza, & Orthopedics, 2009; Devi & Padmanabhan, 2019; Mucedero, Ricchiuti, Cozza, & Baccetti, 2013; Vitria, Tofani, Kusdhany, & Bachtiar, 2019). Based on the variability of prevalence among ethnic races and sexes, Peck et al. (1994) linked palatal displacement of maxillary canines with genetic factors (Jacobs, 1996; S. Peck et al., 1994). Baccetti et al (2010) and Siger et all. (2011) sustained an association between impaction of the maxillary canine and other genetic dental anomalies such as distally displaced mandibular premolars, small latera incisors, and infraocclusion of deciduous molars (Baccetti, 2010; Eid, Ghaleb, Badr, & Marzouk, 2024). On the other hand, Mercuri E. et al. (2013) found no relation between genetic and impaction of the maxillary canine (Mercuri et al., 2013). Scholars advised that the presence of peg-shaped maxillary lateral incisors and other dental anomalies, such as distally displaced or unerupted second premolar, can be considered an early risk indicator for maxillary canine impaction> since such dental anomalies manifest before the maxillary canine eruption. Special attention should be paid to the anticipation of impaction of the maxillary canine(Kolokitha, Balli, Zarkadi, & Gizani, 2023). Mohamad Ali Ranjbaran et al. (2023) claimed that maxillary canine impaction is 3.6 times more prevalent in cases with lateral abnormality (Ranjbaran, Aslani, Jafari-Naeimi, & Rakhshan, 2023).

Ashok Kumar Jena and Ritu Duggal (2010) concluded that no positive association between maxillary canine impaction and anomalous maxillary lateral incisor anomalies. At the same time, they found a high probability of palatal canine impaction when adjacent lateral incisors were anomalous(Jena & Duggal, 2010). On the contrary, Sanja Simić et al. (2019) postulated that the

maxillary lateral incisors on the side with palatally impacted canines were smaller than those on the side where there was no impaction(Simić et al., 2019). This study aimed to investigate the prevalence of the occurrence of maxillary canine impaction in association with peg-shaped maxillary lateral incisors (PSMLI) among Libyan non-syndromic orthodontic patients.

Materials and Methods:

Sample and sampling method:

Initially, 2725 pretreatment orthodontic records of Libyan healthy female and male patients were screened, but after application of inclusion and exclusion criteria, 2650 records were selected. Each pretreatment record should include at least a diagnostic file with pretreatment OPG and the study model, in addition to pretreatment intra-oral photographs if available. The selected records belonged to patients under orthodontic treatment, or the treatment was finished at the moment of sample selection (11-35 years old at the onset of treatment). The records were obtained from the patients' archives in the Department of Orthodontics, Faculty of Dentistry, University of Benghazi, and three other private orthodontic clinics in the city. When exclusion criteria (mentioned below) were applied, 75 records were excluded from the sample because of invalidities such as missing important investigations like OPG, incomplete patient data, inconsistency between diagnosis and investigation findings, syndromic patients including cleft cases, etc. (Figure 1). The sample consisted of 1907 females (72%) and 743 males (28%), making a total of 2650 orthodontic patients who were aged from 11 to 35 years old.

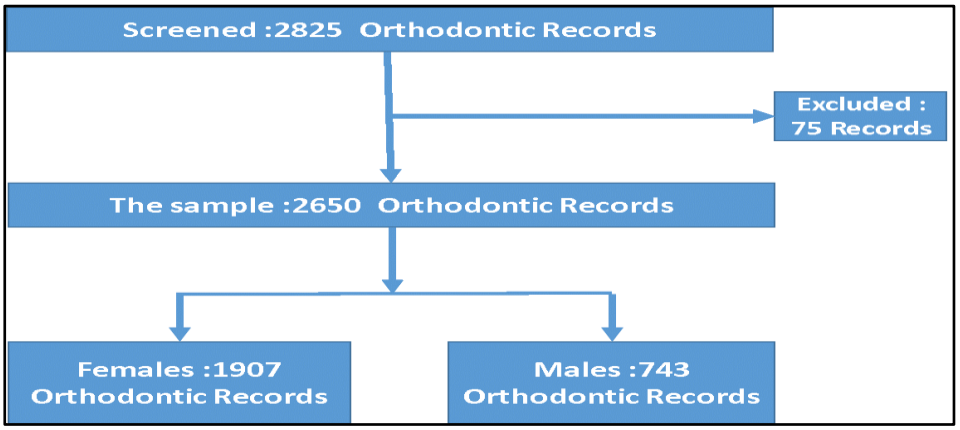

Figure (1): Sample selection

Inclusion Criteria:

i. Libyan orthodontic patient, 11-35 years old at the onset of treatment.

ii. A Patient presented with fully erupted permanent maxillary lateral incisors(s).

iii. No history of extraction of maxillary lateral incisors, trauma, or evaluation of one or more maxillary anterior teeth.
iv. At least one maxillary permanent lateral incisor is clinically present
v. Pretreatment records, including at least the diagnostic file, OPG, and the study models.

Exclusion Criteria:

i. Incomplete pretreatment records, where one or more essential diagnosis tools (the diagnostic file including intra-oral photos, OPG, and the study models) are missing/damaged
ii. Non-Libyan patients
iii. Missing both of maxillary permanent lateral incisors
iv. History of extraction of both maxillary permanent lateral incisors
v. History of trauma/avulsion of maxillary permanent lateral incisors
vi. History of restorative reshaping/crowing of maxillary permanent lateral incisors
vii. Cleft lip and palate and syndromic patients.

The selected pretreatment records were checked by both investigators in two phases. The first phase was searching, confirming the presence of unilateral or bilateral Peg-shaped permanent maxillary lateral incisor (PSMLI). This had been looked for in the diagnosis file for detection, then it was checked in OPG for confirmation and finally examined on the study model for measurements. Once a peg-shaped MLI presence is indicated in the pretreatment diagnostic file, OPG is examined to confirm the diagnosis, since it could be an *"odontoma"* or a supernumerary tooth with a conical shape. Then, measurements were done on the study models where the mesiodistal width of the cervical one-third was compared with the mesiodistal width of the incisal one-third of MLI to confirm that the tooth is peg-shaped (Grahnen, 1956; Mohamed & Muadab, 2024). Once the presence of PSMLI is confirmed, the second phase is done, which is looking for coincident impacted permanent maxillary canines. The collected raw data were organized and tabulated in frequency tables for clarity and ease of handling.

Statistical Analysis:

Descriptive statistical estimations (prevalence and association) of the collected raw data and the inter-examiner reliability testing were performed using the Statistical Package for Social Sciences (IBM® SPSS® Statistics) version 27.

Reliability Testing

For the examiner reliability, 350 records from the sample were examined, and the diagnosis of peg-shaped MLI was made by the investigator twice within one month time period. The intra-examiner kappa test for the agreement was performed using SPSS. The results indicated an excellent intra-examiner agreement according to the Kapp test, ***K*** = 84% (P > 0.05).

Results:

Characteristics of the Sample

*The sample (**n** = 2650 pretreatment orthodontic records) was made up of 1906 records for female patients (72%) and 743 records for males (28%) (Figure 2). Participants' ages ranged from 11 years to 35 years old($\bar{x}$ = 17.07 years old, **s.d.** =5.37 years old) with evident skewed distribution towards younger ages for both genders (Figure* 3). The mean of male's age = 15.52, s.d. = 4.8; while female's mean age = 17.67, s.d. = 5.5. Though this difference between the age means of the two genders was statistically significant (*t = 9.44, p = 0.001*), the effect size was 0.4, which is a minimal effect of the differences between the two means according to Jacob Cohen (Cohen, 2013; Mohamed & Muadab, 2024). Impaction maxillary canine (IMC) was found in 368 cases (13.9%) that were distributed into 114 cases in males (15.3% within the gender) and 254 cases in females (13.3% within the gender). (Table 1). On the right side, there were 289 (10.9 %) peg-shaped maxillary lateral incisors, out of which 50 incisors were right-sided unilateral PSMLI. On the left side, there were 269 (10.2 %), whereas 30 lateral incisors were left-sided unilateral PSMLI. The total of bilateral PSMLI was 239 (9 %) (Table 2).

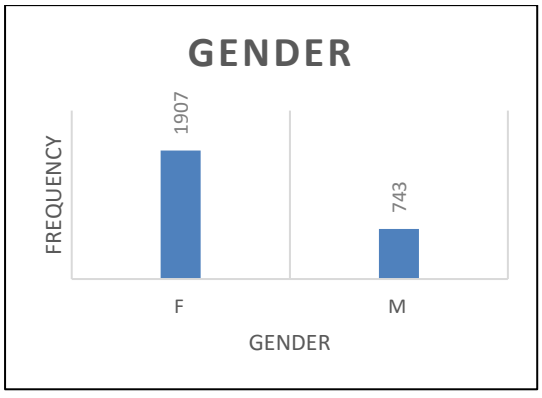

Figure (2): Gender distribution

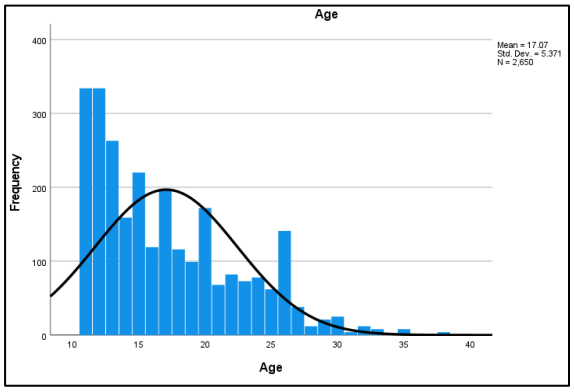

Figure (3): Age distribution of the sample, note a positive skewness toward older age

Table (1): Frequency distribution of canine impaction:

			Maxillary Canine		Total
			Not impacted	impacted	
Gender	f	Count	1653	**254**	1907
		Expected Count	1642.2	264.8	1907.0
		% within Gender	86.7%	13.3%	100.0%
	m	Count	629	**114**	743
		Expected Count	639.8	103.2	743.0
		% within Gender	84.7%	15.3%	100.0%
Total		Count	2282	**368**	2650
		Expected Count	2282.0	368.0	2650.0
		% within Gender	86.1%	13.9%	100.0%

Table (2): Overall frequency distribution of PSMLI (cross tabulation)

			Left Maxillary Lateral Incisor		Total
			No PSMLI	**PSMLI**	
Right Maxillary Lateral Incisor	**No PSMLI**	Count	2331	**30**	2361
		% within R. M. Lateral	98.7%	1.3%	100.0 %
		% within L. M. Lateral	97.9%	11.2%	89.1%
		% of Total	88.0%	1.1%	89.1%
	PSMLI	Count	**50**	**239***	**289***
		% within R. M. Lateral	17.3%	82.7%	100.0 %
		% within L. M. Lateral	2.1%	88.8%	10.9%
		% of Total	1.9%	9.0%	10.9%
Total		Count	2381	**269****	2650
		% within R. M. Lateral	89.8%	**10.2 %**	100.0 %

	% within L. M. Lateral	100.0%	100.0 %	100.0 %
	% of Total	89.8%	10.2%	100.0 %

* : Total of Right sided PSMLI

* *: Total of Left sided PSMLI

***: Total of Bilateral PSMLI

Inferential statistics results:

Right side:

Out of 368 impacted maxillary canines, 38 canines (11%) were found along with PSMLI, whereas 2031 non-impacted canines out of 2282 canines (89%) were found along with normally shaped lateral incisors (not peg-shaped) (Table 3). Chi-Square test revealed no association between presence of PSMLI and impacted permanent maxillary canine ($\bar{\mathbf{x}}$ = *0.148*, ***P*** = *0.390*) Table (4) Fig. (4). An odds ratio (OR) was computed to assess the risk of IMC in association with the presence of PSMLI in the right side resulting in no risk. (OR = 0.932, 95%CI [0.650, 1.336]. Table (5).

Left side:

Out of 368 impacted maxillary canines, 33 canines (9 %) were found along with PSMLI, whereas 2046 non-impacted canines out of 2282 canines (89.7 %) were found along with a normally shaped lateral incisor (not peg shaped) (Table 6) (Figure 5). Chi-Square test revealed no association between the presence of PSMLI and impacted permanent maxillary canine ($\bar{\mathbf{x}}$ = *0.656*, ***P*** = *0.458*) (Table 7). An odds ratio (OR) was computed to assess the risk of IMC in association with the presence of PSMLI on the left side, resulting in no risk. (OR = 0.854, 95%CI [0.583, 1.251]). Table (8).

Bilateral association:

Chi square test revealed an association between the occurrence of one side PSMLI and the occurrence of the same phenomenon on the other side of the maxillary arch ($\bar{\mathbf{x}}$ =1871.884, P =0.001) (Table 9). In addition, the odds ratio (OR) revealed a high risk of occurrence of bilateral PSMLI when either maxillary lateral incisor is peg-shaped. (OR = 371.406, 95% CI = [213.771,595.320]) Table (10).

Table (3): Impacted Maxillary Canine (IMC) VS PSMLI (Right side)

			PSMLI		Total
			No	Yes	
Right Maxillary canine	Not impacted	Count	**2031**	251	2282
		% within Right side	**89.0 %**	**11.0 %**	100.0 %
	Impacted	Count	330	**38**	368
		% within Right side	89.7%	10.3%	100.0 %
Total		Count	2361	289	2650
		% within Right side	89.1%	10.9%	100.0 %

Table (4): Chi-Square test results of Impacted Maxillary Canine (IMC) VS PSMLI (Right side)

	Value	d.f	***P***
Pearson Chi-Square ($\bar{x}$)	**0.148[a]**	1	**0.720**
Continuity Correction	0.087	1	
Likelihood Ratio	0.150	1	**0.720**
Fisher's Exact Test			**0.787**
N of Valid Cases	2650		
a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 40.13.			

Figure (4): IMC VS. Right sided PSMLI

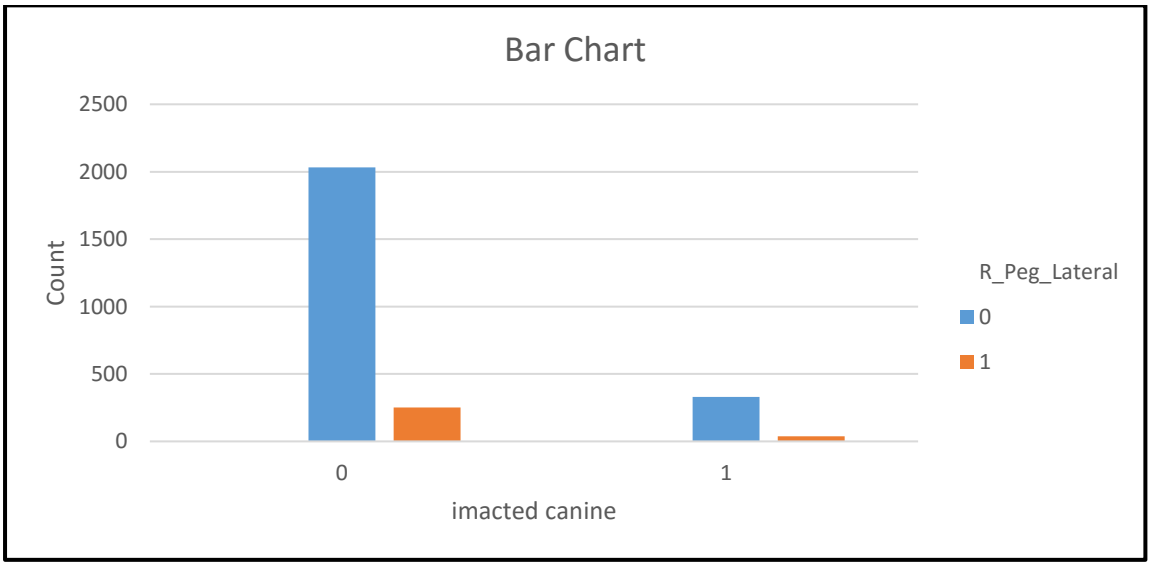

Table (5): IMC Risk Estimate in association with PSMLI (Right side)

	Value	95% CI	
		Lower	Upper
Odds Ratio for Impacted Canine (0 / 1)	**0.932**	**0.650**	**1.336**
For cohort Right Maxillary lateral Incisor = 0	0.992	0.956	1.030
For cohort Right Maxillary lateral Incisor = 1	1.065	0.771	1.471
N of Valid Cases	2650		

0: Absence of the variable (IMC or PSMLI)

1: Presence of the variable (IMC or PSMLI)

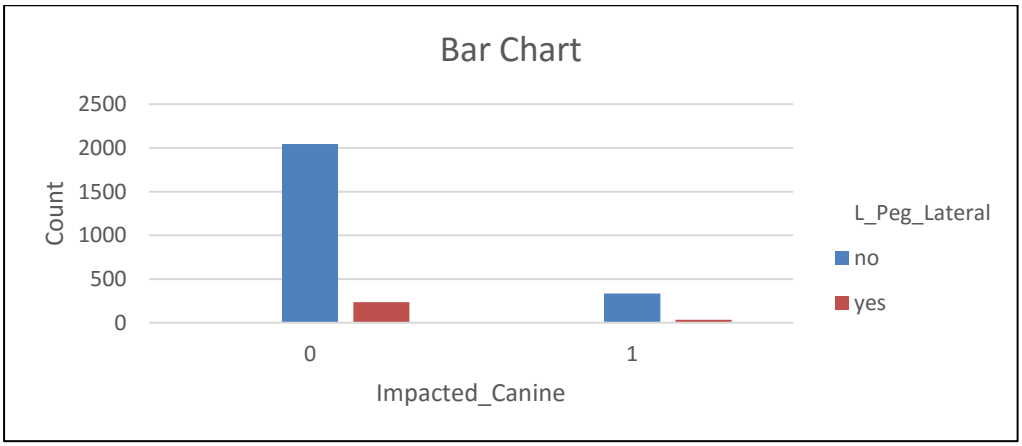

Table (6): Impacted Maxillary Canine (IMC) VS PSMLI (Lef- side)

			PSMLI		Total
			No	**Yes**	
Left Maxillary Canine	**Not Impacted**	Count	**2046**	236	2282
		% within left side	89.7 %	10.3 %	100.0 %
	Impacted	Count	335	**33**	368
		% within left side	**91.0 %**	**9.0%**	100.0 %
Total		Count	2381	269	2650
		% within left side	89.8 %	10.2 %	100.0 %

Table (7):**Chi-Square test ($\bar{x}$) results of Impacted Maxillary Canine (IMC) VS PSMLI (Left side)**

	Value	df	***P***
Pearson Chi-Square ($\bar{x}$)	**.656[a]**	1	0.**458**
Continuity Correction	0.514	1	
Likelihood Ratio	0.677	1	0.458
Fisher's Exact Test			0.458
N of Valid Cases	2650		
a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 37.6.			

Table (8): IMC Risk Estimate in association with PSMLI (left side)

	Value	95% CI	
		Lower	Upper
Odds Ratio for Impacted Canine (0 / 1)	**0.854**	**0.583**	**1.251**
For cohort Left Maxillary lateral Incisor = 0	0.985	0.951	1.020
For cohort Left Maxillary lateral Incisor = 1	1.153	0.815	1.632
N of Valid Cases	2650		

Table (9): Chi-Square test ($\bar{x}$) of association between right and left-side PSMLI

	Value	**df**	***P***
Pearson Chi-Square ($\bar{x}$)	**1871.884[a]**	1	**0.000**
Continuity Correction	1862.967	1	
Likelihood Ratio	1152.652	1	0.000
Fisher's Exact Test			0.000
N of Valid Cases	2650		
a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 29.34.			

Table (10): Risk Estimate in association of right and left sided PSMLI

	Value	95% CI	
		Lower	Upper
Odds Ratio for Right Maxillary Lateral incisor (0 / 1)	**371.406**	**231.711**	**595.320**
For cohort Left Maxillary lateral Incisor = 0	5.707	4.435	7.343
For cohort Left Maxillary lateral Incisor = 1	.015	0.011	0.022
N of Valid Cases	2650		

Discussion:

In orthodontics, developmentally malformed permanent maxillary lateral incisors, particularly peg-shaped lateral incisors, and malposition of impacted maxillary canines have massively attracted the attention since the two teeth are fundamental player in dental esthetics and functions(Becker, Sharabi, & Chaushu, 2002; Sajnani & dentistry, 2015). Both of the phenomena

are suspected to be interrelated, and association has been considered on several occasions(Aydin, Yilmaz, & Yildirim, 2004; Becker et al., 2015). One of the theories that explains the phenomenon of impacted permanent maxillary canines in human beings is the guidance theory(Papageorgiou et al., 2025). This theory stands for the essential role of the maxillary lateral incisor's root in the eruption of the maxillary canine in its normal position; therefore, for normal development of the maxillary canine, a guide should be pre-established, which is the distal aspect of the lateral incisors. In other words, if the lateral incisor is not normally developed or undersized, the maxillary canine loses the pathfinder for normal development and eruption (Sajnani & dentistry, 2015).

Association between PSMLI and IMC:

The two phenomena, whether together or separated, are usually the main concern of dentists in general, specifically orthodontists. Hence, one of the most substantial data sources is the orthodontic patients (Mohamed & Muadab, 2024). This study was applied to a sample of 2650 orthodontic files of males and females in Benghazi, Libya, to investigate the level of association odds ratio of the occurrence of impaction of permanent canines in the presence of PSMLI. The query asked is whether may malformed or peg-shaped maxillary lateral incisor considered an indicator of maxillary canine impaction? This issue has been massively investigated, with no final decision made(Papageorgiou et al., 2025). This study found no association between IMC and PSMLI (***P > 0.05***) (Table 4, 7), moreover, the odds ratio (OR) value was less than 1 in case of the right and the left sides (Right side: OR = 0., 95%CI [0.650, 1.336]) (Table 5), (Left side: OR = 0.854, 95%CI [0.583, 1.251]) (Table 8). Noticing that the 95% confidence interval on both sides (right and left maxillary lateral incisors) includes 1, which means insignificance, in other words, no association between the two phenomena. These findings indicate that PSMLI cannot be considered a reliable predictor for IMC. The findings of this study goes well with find of Ashok Kumar Jena and Ritu Duggal (Jena & Duggal, 2010) who investigated the association between the two phenomena and concluded that PSMLI cannot be consider as a trustable indicator for IMC, and gender has no effect on the prevalence of occurrence of PSMLI and IMC together.

On the contrary, Kim J H et al revealed a statistically significant association between palatal displaced maxillary canines and PSMLI (OR = 9.00 [95% CI: 4.017–20.162]) (J.-H. Kim, Choi, & Kim, 2017). Remarkably, Kim et al based their conclusion on results of an investigation made on 3,834 children aged 7–15 years old. This can explain the difference between this study's

conclusion and theirs. Since the larger sample size and applying a study to a limited range of ages are factors that lead to statistical significance (Walters, Campbell, & Machin, 2021). Moreover, basing on the fact that root completion of the maxillary lateral incisors is at about 10-11 years, and eruption of maxillary canine is at about 12 years (Kotsanos, Sarnat, & Park, 2022), so a considerable part of their sample cannot be reliable source of data in regards with the association between the two phenomena. Kolokitha et al. claimed that the presence of PSMLI and infra-occlusion of deciduous molars can be considered a major, valuable early risk indicator for maxillary canines (Kolokitha et al., 2023). The difference between this study's findings and theirs can be owed to the fact that they investigated the association between the IMC and the presence of both PSMLI and infra-occlusion of deciduous molars. Peck S et al. (S. Peck, Peck, Kataja, & orthopedics, 1996) concluded that morphologically abnormal maxillary lateral incisors and impacted maxillary canines are biologic co-variables, however, they confirmed the genetic influence in this association.

Several studies have confirmed genetic and other factors that can influence the prevalence of IMC. (Becker et al., 2015). Factors such as arch to teeth size discrepancy, anatomical obstacles, dental agenesis, etc., two or more of which should be coincident to cause maxillary canine impaction (Jacoby, 1983)

Effect of side on the prevalence of PSMLI:

This study concluded a highly significant association between the occurrence of PSMLI on one side (unilateral) and its occurrence on the other side. In other words, the difference in the prevalence of unilateral PSMLI and bilateral PSMLI is statistically significant x=1871.884, P =0.001) (Table 9). (OR = 371.406, 95% CI = [213.771,595.320]) (Table 10). However, this study found that the prevalence right right-sided PSMLI was 289, 10.9% and 269, 10.2 % for the left-sided PSMLI, with a significant association ($\bar{x}$ = *18871.881, p = 0.001*)

Effect of gender on the prevalence of PSMLI:

In regards with the right side there was insignificant effect of gender on the prevalence of PSMLI, though the males showed higher prevalence of right side PSMLI than females (12.5% & 10.3%respectively) this difference found to be statistically insignificant ($\bar{\mathbf{x}}$ = 2.758, p = 0.057) (OR = 1.249 95% CI [0.960, 1.624]). In contrast, the difference between males and females in the prevalence of PSMLI (12.7% & 9.2% respectively) was statistically significant ($\bar{\mathbf{x}}$ =7.078, p = 0.005) (OR = 1.433, 95% CI [1.098 &1.871]).

Conclusions:

- Since there is no association between the prevalence of PSMLI and the prevalence of IMC, the presence of PSMLI is not a reliable risk indicator for IMC.
- Maxillary canine impaction is a multifactorial phenomenon (including genetic influence) which does not depend on the presence of PSMLI only.
- Right-sided PSMLI is significantly more prevalent than left-sided PSMLI. Bilateral PSMLI is significantly more prevalent than unilateral.

References:

- Afify, A. R., & Zawawi, K. H. J. I. S. R. N. (2012). The prevalence of dental anomalies in the Western region of Saudi Arabia. *2012*(1), 837270.
- Aydin, U., Yilmaz, H., & Yildirim, D. J. D. R. (2004). Incidence of canine impaction and transmigration in a patient population. *33*(3), 164-169.
- Baccetti, T. (2010). *Risk indicators and interceptive treatment alternatives for palatally displaced canines.* Paper presented at the Seminars in Orthodontics.
- Baccetti, T., Mucedero, M., Leonardi, M., Cozza, P. J. A. J. o. O., & Orthopedics, D. (2009). Interceptive treatment of palatal impaction of maxillary canines with rapid maxillary expansion: a randomized clinical trial. *136*(5), 657-661.
- Becker, A., Chaushu, S. J. A. J. o. O., & Orthopedics, D. (2015). Etiology of maxillary canine impaction: a review. *148*(4), 557-567.
- Becker, A., Sharabi, S., & Chaushu, S. J. T. E. J. o. O. (2002). Maxillary tooth size variation in dentitions with palatal canine displacement. *24*(3), 313-318.
- Cohen, J. (2013). *Statistical power analysis for the behavioral sciences*: routledge.
- Devi, M. A., & Padmanabhan, S. J. J. o. O. (2019). Role of polymorphisms of MSX1 and PAX9 genes in palatal impaction of maxillary canines. *46*(1), 14-19.
- Eid, F. Y., Ghaleb, S. I., Badr, F. F., & Marzouk, E. S. J. B. O. H. (2024). Three-dimensional assessment of the skeletal characteristics accompanying unilateral maxillary canine impaction: a retrospective cone-beam computed tomography study. *24*(1), 1249.
- Grahnen, H. (1956). *Hypodontia in the permanent dentition. A clinical and genetical investigation. Odontological Review 7, Supplement 3.* Thesis,
- Herrera-Atoche, J. R., Agüayo-de-Pau, M. d. R., Escoffié-Ramírez, M., Aguilar-Ayala, F. J., Carrillo-Ávila, B. A., & Rejón-Peraza, M. E. J. I. J. o. D. (2017). Impacted maxillary canine prevalence and its association with other dental anomalies in a Mexican population. *2017*(1), 7326061.
- Jacobs, S. G. J. A. d. j. (1996). The impacted maxillary canine. Further observations on aetiology, radiographic localization, prevention/interception of impaction, and when to suspect impaction. *41*(5), 310-316.
- Jacoby, H. J. A. j. o. o. (1983). The etiology of maxillary canine impactions. *84*(2), 125-132.
- Jena, A. K., & Duggal, R. J. J. o. C. P. D. (2010). The pattern of maxillary canine impaction in relation to anomalous lateral incisors. *35*(1), 37-40.

- Kim, J.-H., Choi, N.-K., & Kim, S.-m. J. J. o. C. P. D. (2017). A retrospective study of association between peg-shaped maxillary lateral incisors and dental anomalies. *41*(2), 150-153.
- Kim, Y., Hyun, H.-K., & Jang, K.-T. J. T. A. O. (2017). Morphological relationship analysis of impacted maxillary canines and the adjacent teeth on 3-dimensional reconstructed CT images. *87*(4), 590-597.
- Kolokitha, O.-E., Balli, D., Zarkadi, A.-E., & Gizani, S. J. E. A. o. P. D. (2023). Association between maxillary canine impaction and other dental anomalies: radiological study of a mixed dentition children's cohort from an orthodontic clinic. *24*(3), 401-407.
- Kotsanos, N., Sarnat, H., & Park, K. (2022). *Pediatric dentistry*: Springer Nature.
- Lövgren, M. L., Dahl, O., Uribe, P., Ransjö, M., & Westerlund, A. J. E. J. o. O. (2019). Prevalence of impacted maxillary canines—An epidemiological study in a region with systematically implemented interceptive treatment. *41*(5), 454-459.
- Mercuri, E., Cassetta, M., Cavallini, C., Vicari, D., Leonardi, R., & Barbato, E. J. T. A. O. (2013). Dental anomalies and clinical features in patients with maxillary canine impaction: a retrospective study. *83*(1), 22-28.
- Mohamed, M., & Muadab, H. J. S. C. P. (2024). Prevalence of Peg-Shaped Permanent Maxillary Lateral Incisors, Among Non-Syndromic Libyan Orthodontic Patients. *1*(1), 1-7.
- Mucedero, M., Ricchiuti, M. R., Cozza, P., & Baccetti, T. J. T. E. J. o. O. (2013). Prevalence rate and dentoskeletal features associated with buccally displaced maxillary canines. *35*(3), 305-309.
- Papageorgiou, S. N., Seehra, J., Cobourne, M. T., Kanavakis, G. J. O., & research, c. (2025). Does Current Evidence Support the Discussion Around the Guidance Theory? A Systematic Review and Meta-Analysis on the Association Between Maxillary Lateral Incisor Agenesis and Displacement or Impaction of the Permanent Canine. *28*(2), 312-323.
- Peck, S., Peck, L., Kataja, M. J. A. j. o. o., & orthopedics, d. (1996). Prevalence of tooth agenesis and peg-shaped maxillary lateral incisor associated with palatally displaced canine (PDC) anomaly. *110*(4), 441-443.
- Peck, S., Peck, L., & Kataja, M. J. T. A. O. (1994). The palatally displaced canine as a dental anomaly of genetic origin. *64*(4), 250-256.
- Peck, S. J. A. J. o. O., & Orthopedics, D. (2016). Misleading article on palatally displaced canines. *149*(2), 149-150.

- Ranjbaran, M. A., Aslani, F., Jafari-Naeimi, A., & Rakhshan, V. J. I. O. (2023). Associations among the occurrence or types of maxillary canine impaction, labial frenum attachment types, lateral incisor anomalies, and midline diastema in patients with and without impaction: A case-control study. *21*(2), 100743.
- Russell, K. A., & McLeod, C. E. J. T. C. P.-C. J. (2008). Canine eruption in patients with complete cleft lip and palate. *45*(1), 73-80.
- Sajnani, A. K. J. J. o. i., & dentistry, c. (2015). Permanent maxillary canines–review of eruption pattern and local etiological factors leading to impaction. *6*(1), 1-7.
- Sambataro, S., Baccetti, T., Franchi, L., & Antonini, F. J. T. A. O. (2005). Early predictive variables for upper canine impaction as derived from posteroanterior cephalograms. *75*(1), 28-34.
- Simić, S. M., Pavlović, J., Nikolić, P. V., Vujačić, A., Vukićević, V., & Jovanović, R. J. V. p. (2019). The prevalence of peg-shaped and missing lateral incisors with maxillary impacted canines. *76*(1).
- Stellzig, A., Basdra, E., & Komposch, G. J. F. d. K. (1994). On the etiology of upper canine impaction—a space analysis. *55*, 97-103.
- Vitria, E. E., Tofani, I., Kusdhany, L., & Bachtiar, E. W. J. F. (2019). Genotyping analysis of the Pax9 Gene in patients with maxillary canine impaction. *8*, 254.
- Walters, S. J., Campbell, M. J., & Machin, D. (2021). *Medical statistics: a textbook for the health sciences*: John Wiley & Sons.