Maxillary Canine Impaction in Subjects Aged 14 Years and Older: A Cross-Sectional Study

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Objectives: This cross-sectional study aimed to estimate the prevalence of impacted maxillary canines in patients seeking treatment from 2016-2020 at the University of Puerto Rico School of Dental Medicine Orthodontic Graduate Program and compare it to the prevalence of published reports. Additionally, we sought to describe the clinical pattern of impaction using initial photographs and panoramic radiographs.

Materials and Methods: Data were extracted from the dental records aged 14 years and older who had sought orthodontic treatment in 2016-2020. A calibrated examiner conducted all the dental measurements using 2D images from the initial records. Descriptive statistics included means (standard deviations), medians (interquartile range), and frequencies. A one-sample binomial test was used to compare the prevalence found to those of published reports. A chi-square, Fisher's exact, and the Mann–Whitney tests were used to compare patients with and without impaction. We used logistic regression to evaluate the associations between tooth-level risk factors and impaction, accounting for clustering and adjusting for age and sex.

Results: The study included 217 patients (mean age: 21.38 ± 9.16 years; 58.5% were female). The prevalence of maxillary canine impaction was 7.83%. The odds of impaction were higher if the deciduous canine was present (OR = 67.59; 95% CI: 18.61-245.40) or if the canine overlapped the lateral incisor root (OR = 155.92; 95% CI: 36.32-669.29).

Conclusion: The overall prevalence of maxillary canine impaction was high, although parallel to that reported in a Mexican population; site-level risk factors (deciduous canine presence, overlap) were identified.

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Teeth may be considered delayed in their eruption into the oral cavity, when a considerable time after the standard timing of eruption has passed (1,2). The disruption of eruption timing may lead to abnormal dental occlusion (1). It may be difficult to differentiate between impacted and unerupted teeth based on the timing of dental development. In a study of the synchronicity of the timing of the eruption of contralateral teeth, it was suggested that the failure of a contralateral tooth to erupt within 4 months of its counterpart, might serve as a criterion for the diagnosis of delayed eruption of permanent teeth (1,3).

Maxillary canines are the second most frequently impacted teeth (4,5), and while the exact cause of such impaction remains unknown, various risk factors and variables have been hypothesized to play a role. Multifactorial and genetic origins have been attributed to this dilemma, as well (4).

The Index of Orthodontic Treatment Need, first described by Peter H. Brook and William C. Shaw (1989) and later modified by Stephen Richmond in 1990, places the impaction of maxillary canines in a "needs treatment" category, establishing the importance of diagnosis and intervention.

In a recent study by Alejos-Montante (6) and colleagues, the prevalence of maxillary canine impaction was reported to be 5.64% in a sample of children being treated at a dental school clinic in Mexico, while in a study of a Saudi Arabian population, the prevalence was determined to be 1.9% (2). In concordance with the mentioned reports, a study of a Saudi Arabian population (in the city of Najran) found the prevalence of maxillary canine impaction in this population to be 3.46% (7). A female predilection was reported in most of the mentioned studies, which is in accordance with previous reports found in the literature (2, 6–9).

The diagnosis of any kind of orthodontic patient requires thorough clinical and radiographic assessments; 2D imaging, easy both to use and understand, can provide the latter and is especially valuable in evaluating canine impactions. Panoramic radiography is a technique that is readily available to the general dental practitioner as well as to specialists in the dental field and can be used when communicating the details of a given case to both the patient and relevant colleagues. By classifying panoramic radiographic images of canine impaction during the

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initial evaluation, descriptive findings can be obtained. A detailed description of maxillary canine impaction will provide a tool for explaining findings to patients during case presentations since not all impactions are the same.

Numerous studies have attempted to examine and describe the angulation and position of impacted maxillary canines. Some studies consider multiple variables such as angulation and position in reference to adjacent anatomical structures (8). Other ways of taxonomizing, such as the Yamamoto classification used in the study of the Saudi Arabian (7) population of Najran, might be considered too complex and therefore may not be widely used. The use of complex classifications and/or complex tools or terminology is undesired by many providers when presenting findings to patients. Descriptions of crowding, cervical vertebrae maturation (3), arch shape, and form by visual assessment (3) continues to be of daily use during the initial overall case evaluation. A simple descriptive analysis of maxillary canine impaction might demystify and simplify the description of the pattern of maxillary canine impaction during the initial case assessment.

The purpose of our research was to estimate, by means of a cross-sectional study, the prevalence of impacted maxillary canines in patients seeking orthodontic treatment (2016-2020) from the University of Puerto Rico School of Dental Medicine (UPRSDM) Orthodontic Graduate Program and compare that prevalence with the prevalence estimates of several published reports. Additionally, we sought to describe the clinical pattern of impaction with the use of the initial photographs and panoramic radiographs.

Materials and Methods

Enrollment and inclusion/exclusion criteria

The dental records of the patients who participated in this cross-sectional descriptive study were stored on a digital system from Dolphin Imaging & Management Solutions (Patterson Dental Supply, Inc., Chatsworth, CA, USA) and on axiUm from Exan Software (Las Vegas, NV, USA). These patients had been evaluated (2016-2020) at the clinic of the UPRSDM Graduate Orthodontic Program and met the study's inclusion criteria.

The principal investigator and one undergraduate student were responsible for examining the list of potential participants and determining their eligibility for enrollment in the study. The inclusion criteria were the following: patients who were documented in the files of the clinic of the Orthodontic Graduate Program from 2016 through 2020 (via the Dolphin and axiUm digital systems), were 14 years or older, were seeking orthodontic treatment, had a complete initial record containing a panoramic radiograph and initial intraoral photographs, and had no previous extractions apart from 1 or more third molars. We excluded persons with previous orthodontic treatment, syndromic patients (with history of craniofacial disorders), patients with tooth agenesis and individuals with a history of a cleft lip and/or cleft palate.

Patient confidentiality and variables by definition and description

After the institutional review board's approval (IRB 0640321), the principal investigator and the undergraduate student extracted the subjects' records from the files, determined the eligibility of those subjects for the study, and, to comply with confidentiality, assigned a code to each eligible subject.

Information on patient-related characteristics, such as each patient's age and biological sex, that individual's family history of orthodontic issues or orthodontic treatment, and the highest level of education in the person's household (less than high school diploma, high school diploma, higher than high school diploma, not reported) were obtained from each patient's dental records, which were themselves based on self-reports.

Assessment of study outcome

The main outcome of this study was maxillary canine impaction (yes/no), which was assessed by reviewing intraoral photographs and panoramic radiographs. A maxillary canine was considered impacted if the canine's dental crown had not perforated the oral mucosa and was not visible in the oral cavity (determined using intraoral photographs), and its existence was corroborated using the accompanying panoramic radiograph. For each patient under study, both the left and the right maxillary quadrants were evaluated; an affected tooth was categorized as being either unilaterally or bilaterally impacted, based on the pattern of impaction. An assessment of the main study outcome, as well as of other clinical variables, was conducted by a single examiner (AAP).

Assessment of additional clinical characteristics

The presence of a deciduous canine (yes/no) in a given patient was determined using the pertinent intraoral photograph and confirmed by means of that individual's panoramic radiograph. Positive ("yes") findings were represented by the number 1 and negative ("no") findings, the number 0; all were placed on the data table.

Using a straight-edged instrument, a panoramic midline was drawn through the nasal septum which was determined by the radiographic anterior nasal spine. The angulation of the impacted maxillary canine in reference to the panoramic midline was determined based on the evaluation of panoramic radiographs and was categorized as being either 45 degrees or more or less than 45 degrees. The midline of the maxillary canine was determined using the cusp and root apex as reference points. The inclination of the maxillary canines in reference to the panoramic midline was established and documented.

Overlap (yes/no) was determined based on a visual evaluation of the panoramic radiograph; the maxillary canine was considered to be overlapping if the cusp tip of the canine was superimposed on the lateral incisor root on the panoramic radiograph. Additionally, when the overlap was present, we recorded whether it was located on the distal or mesial half of the lateral incisor.

The vertical position of the canine in reference to the lateral incisor root was recorded after a visual inspection of the panoramic radiograph was made. First, the mid-root of the maxillary lateral incisor was identified using the distance equidistant between the apex and cemento-enamel junction. Subsequently, the position of the maxillary canine cusp was evaluated in reference to the mid-root of the lateral incisor. The vertical position of the impacted canine was categorized as either on the apical half or beyond or on the cervical half.

Training and calibration

Prior to data collection for the study, the study examiner (AAP) and an experienced orthodontic department faculty member (FP, considered the gold-standard examiner) participated in a calibration exercise using the intraoral photographs and panoramic radiographs of 14 patients who were evaluated outside the eligible time period (before 2016 or after 2020). Measurements were repeated by each examiner within a period of 1 month. Inter-examiner and intra-examiner kappa coefficients were calculated for all the clinical measures. The reliability of each measurement was found to be excellent for both intra- and inter-examiner comparisons (all the kappa coefficients were 1.00, with a 95% CI: 1.00-1.00).

Statistical analysis methods

Means (standard deviations) and medians (interquartile range) were used to describe continuous variables; frequencies (percentages) were calculated for categorical variables. The normality of the distribution of continuous variables was tested using the Shapiro–Wilk normality test. One-sample binomial test was used to compare the prevalence we found to those of published. Chi-square or Fisher's exact test was used to compare the distribution of impaction (yes/no) in groups defined by categorical risk factors, as appropriate. The Mann–Whitney test was employed to compare the ages of the participants. The association between tooth-level risk factors (such as overlap and the presence of a deciduous canine) were further explored in logistic regression models while also accounting for the clustering of evaluated canines within the patient. Unadjusted and age- and sex-adjusted models were considered; odds ratios (ORs) (95% confidence intervals) were reported. All the tests were 2-sided and conducted at a .05 level of statistical significance. All the analyses were conducted using the SAS statistical software, version 9.4 (SAS Institute, Cary, NC, USA).

Results

Data were extracted from the files of 347 patients (Figure 1). A total of 130 (37.75%) patients were excluded, and the reasons for their exclusion were having incomplete records (n = 2; 1 female, 1 male), having had previous orthodontic treatment (n = 11; 7 females, 4 males), having a syndrome and/or cleft lip or palate (n = 24; 12 females, 12 males), having had previous dental extractions other than third molars (n = 77; 52 females, 25 males), and suffering from tooth agenesis (n = 16; 12 females, 4 males).

Figure 1. Study participants' selection flow chart

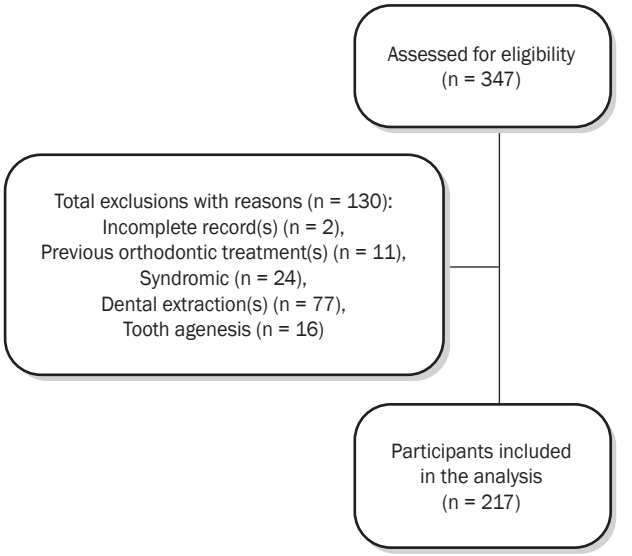

Table 1. Patient characteristics in the overall study sample (n = 217), and by canine impaction (yes/no)

Characteristic	All the participants (n = 217)	Participants with impaction(s) (n = 17)	Participants without impaction(s) (n = 200)	*P* value
Age, years				
Mean (±SD)	21.38 (±9.16)	16.90 (±3.82)	21.77 (±9.39)	<.01**
Median (IQR)	17.67 (15.67-23.42)	16.00 (14.50-17.00)	17.88 (15.75-24.54)	
Biological sex, n (%)				
Male	90 (41.47)	9 (52.94)	119 (59.50)	.32
Female	127 (58.53)	8 (47.06)	81 (40.50)	
Highest educational level in the household, n (%)				
More than a high school diploma	17 (7.83)	0 (0)	17 (8.50)	.17
High school diploma	9 (4.15)	1 (5.88)	8 (4.00)	
Less than a high school diploma	24 (11.06)	4 (23.52)	20 (10.00)	
Not answered	167 (76.96)	12 (70.53)	155 (77.50)	
Family history of orthodontic issues and/or treatment, n (%)				
Yes	5 (2.30)	0 (0)	5 (2.50)	1.0
No/not answered	212 (97.70)	17 (7.83)	195 (97.50)	

Abbreviations: IQR, interquartile range
P values were obtained using the Mann–Whitney test for age, the chi-square test for sex, and Fisher's exact test for educational level and family history.
** *P* < .01

The study sample for analysis consisted of 217 patients (Table 1) with a mean age of 21.38 (±9.16) years and a median age of 17.67 years (interquartile range: 15.67-23.42); more than half of our participants (58.25%) were female. Seventeen (7.83%, 95% CI: 4.26-11.41) participants had impactions, with a total of 19 maxillary canines being impacted. The impaction prevalence in our study was significantly different from two previous reports (both from Saudi Arabia), which estimated the prevalence at 1.9% (2) and 3.46% (7), with one-sample binomial test *P* values of less than .0001 and less than .001, respectively. On the other hand, our prevalence estimate was not statistically significantly different from that reported by a study conducted in a Mexican (6) population (5.64%; $P = .16$). Most of the participants in our study with impaction had unilateral impactions: 9 participants (5 females and 4 males) had right canine impactions; 6 participants (2 females and 4 males) had left-side impactions; 2 participants (1 female and 1 male) had bilateral impactions.

The participants with 1 or more impactions were younger (mean age: 16.9 years ± 3.82; median: 16 years) than those without any impactions (mean age: 21.77 years ± 9.39; median: 17.88 years), with the *P* value for the Mann–Whitney test being less than .01. The prevalence of impaction in the males was somewhat higher (9, or 10% of all males) than it was in the females (8 participants, or 6.30%); however, these differences were not statistically significant (chi-square $P = .32$).

The highest level of household education most frequently reported was "less than high school diploma" (24 participants, or 11.06%); however, most of the participants (76.96%) did not report the education level of their household. A family history of orthodontic issues or orthodontic treatment was reported by 5 participants (2.30%) in the overall sample; none of the patients with said reported family history were in the maxillary canine impaction category.

An angulation of 45 degrees or more was found in 10 (52.63%) (Table 2) of the maxillary quadrants of the impacted group, but not in the quadrants without impaction ($P \leq .001$). Canine overlap in relation to the lateral incisor was more frequent in quadrants with impaction (83.68%) compared to those without impaction (1.45%) ($P < .0001$).

In regression analysis (Table 3), maxillary quadrants with a deciduous canine present had 92.47 times higher odds (95% CI: 24.51-348.87) of also having permanent canine impactions; this association was slightly attenuated when adjusted for age and sex;

Table 2. Tooth-related characteristics in all evaluated maxillary quadrants (n = 434), and by canine impaction (yes/no)

Characteristic	All the quadrants (n = 434)	Maxillary quadrants with canine impaction(s) (n = 19)	Maxillary quadrants without canine impaction(s) (n = 415)	*P* value
Deciduous canine present, n (%)	13 (2.99)	9 (47.37)	4 (0.96)	<.0001****
Canine angulation in reference to the anatomical midline, n (%)				
≥ 45°	10 (2.30)	10 (52.63)	0 (0)	<.0001****
<45°	424 (97.69)	9 (47.37)	415 (100)	
Canine overlap related to lateral incisor, yes/no, n (%)				
Yes	20 (4.60)	14 (73.68)	6 (1.45)	<.0001****
No	414 (95.39)	5 (26.32)	409 (98.55)	
Canine overlap related to lateral incisor, 3 categories, n (%)				
Mesial	10 (2.30)	8 (42.11)	2 (0.48)	<.0001****
Distal	10 (2.30)	6 (31.58)	4 (0.96)	
None	414 (95.39)	5 (26.32)	409 (98.55)	
Vertical position of the canine in reference to lateral incisor root, n (%)				
Apical half or beyond	8 (1.84)	8 (42.11)	0 (0)	<.001***
Cervical half	11 (2.53)	11 (57.89)	0 (0)	
Neither	415 (95.62)	0 (0)	415 (100)	

**** $P < .0001$; *** $P < 0.001$.

Table 3. Odds ratios (95% confidence intervals) for impaction (yes/no), according to patient risk factors

Risk factors	Unadjusted OR (95% CI)	*P* value	Age- and sex-adjusted OR (95% CI)	*P* value
Presence of deciduous canine, yes/no	92.47 (24.51-348.87)	<.0001****	67.59 (18.61-245.40)	<.0001****
Overlap, yes/no	190.87 (45.26-804.87)	<.0001****	155.92 (36.32-669.29)	<.0001****

Abbreviation: OR, odds ratio
**** $P < .0001$

however, it remained statistically significant (OR = 67.59; 95% CI: 18.61-245.40). In age- and sex-adjusted models, overlapping teeth had 155.92 times higher odds of being impacted (95% CI: 36.32-669.29).

Discussion

The present study not only evaluated the prevalence of maxillary canine impaction in subjects aged 14 years old and older seeking orthodontic treatment at the UPRSDM during the years of 2016 through 2020 but also described the patterns of these impactions and explored the patient- and tooth-level characteristics potentially associated with impaction.

In our study, we found the prevalence (of maxillary canine impaction) to be 7.83% (n = 17) in the participating patients at the clinic of the UPRSDM Orthodontic Graduate Program. The prevalence of maxillary canine impaction was found to be 5.64% in a sample of children being treated at the dental school clinic in Mexico (6), while prevalences of 1.9% and 3.46%, respectively, were found in a study population at the Jazan University College of Dentistry in Jazan, Saudi Arabia (2), and in a population from Najran, Saudi Arabia (7).

Female predilection was seen in most studies in the literature (9). In the population of Jazan, Saudi Arabia, maxillary canine impaction was found in 69.4% of the women and only 30.6% of the men (2). Similar findings were observed in the Najran, Saudi Arabia (7), population, in which a higher prevalence was reported in females (58.38%) than in males (41.62%), and in the Mexican (6) population of Alejos-Montante et al., in which a significant female predilection was reported ($P = .034$). Our observations do not coincide with those found in the literature reporting higher prevalences in males than females. Although the odds of impaction appear to be higher for males in our findings, the results were not statistically significant.

Regression analysis showed that maxillary quadrants with deciduous canines, as well as quadrants with 1 or more overlaps, had higher odds of containing impactions. Quadrants containing canines with angulations of 45 degrees or more were found to have a statistically significant association with maxillary canine impactions, according to a chi-square analysis. Further adjustment of this association for age and sex (in regression analysis) was not feasible due to the lack of cases with 45 degrees or greater angulation in the non-impacted group (separation of data). It must be declared that the results reflect the small population of individuals with impacted teeth included in this sample, so these results may not necessarily be extrapolated to other populations.

There are many patient- and tooth-level characteristics that can lead to the permanent canine impactions, and this unfortunate reality presents a challenge. Panoramic radiography, which is easy to use, may facilitate the classification of canine impactions during case assessment and presentation.

The strengths of this study include its use of panoramic radiography, a technique that is readily available to both general dental practitioners as well as specialists in the field and is widely utilized worldwide. The visual nature of panoramic radiography makes them a perfect vehicle for transmitting information to the patient, as well as for creating urgency in colleagues when referral to a specialist is warranted. By classifying panoramic radiographic images of canine impaction during the initial evaluation in complex cases, the need for cone-beam computed tomography can be clearly established and incorporated in an accompanying referral. To our knowledge, no study exploring the prevalence of impacted maxillary canines has been performed by any member or members of the Orthodontic Graduate Program of the UPRSDM, this one then, would appear to be the first.

This study had some limitations: The design was cross-sectional, and the study sample was small, affecting the precision of our estimates. The results do not reflect the labial or palatal position of the impacted maxillary canines, which may affect the final position in the oral cavity. The results may not necessarily be extrapolated to a larger population.

Future studies that include all the orthodontic patients who attend the institution's pediatric clinic, undergraduate clinic and Private Practice, are recommended.

Conclusions

The overall prevalence of maxillary canine impaction in our sample was high and was similar to that reported by Alejos-Montante et al. for their sampled Mexican population. The odds of impaction were higher if a deciduous canine was present or if a permanent maxillary canine overlapped the root of the lateral incisor.

Resumen

Objetivos: El propósito de este estudio transversal fue estimar la prevalencia de caninos maxilares impactados entre los pacientes que buscaron tratamiento en el Programa Graduado de Ortodoncia de la Facultad de Medicina Dental de la Universidad de Puerto Rico durante 2016-2020 y compararlo con informes publicados. Además, se buscó describir el patrón clínico de las impactaciones. Materiales y métodos: Los datos fueron extraídos de expedientes dentales de pacientes de 14 años o más que buscaron tratamiento entre 2016-2020. Un examinador calibrado realizó las mediciones dentales basadas en imágenes 2D. La estadística descriptiva incluyó medias (desviaciones estándar), medianas (rango intercuartílico) y frecuencias. Se utilizó una prueba binomial de una muestra para comparar la prevalencia a informes publicados. Se utilizaron pruebas de Chi-cuadrado, exacta de Fisher y de Mann–Whitney para comparar características generales y modelos de regresión logística para evaluar las asociaciones entre los factores de riesgo a nivel dental, tomando en consideración agrupaciones, el ajuste por edad y sexo; se informaron razones de probabilidad (intervalos de confianza de 95%). Resultados: El estudio abarcó 217 pacientes (edad media: 21.38 ±9.16 años; 58.5% mujeres). La prevalencia de impactación canina maxilar fue de 7.83%. Las probabilidades de impactación aumentaban con la presencia del canino caducifolio (OR=67.59; IC 95%: 18.61-245.40), o si el canino presentaba superposición con la raíz lateral (OR=155.92; IC 95%: 36.32-669.29). Conclusión: La prevalencia general de impactación canina maxilar fue alta, aunque similar al informe de una población mejicana; se identificaron factores de riesgo (presencia canina caducifolia y superposición).

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