

Prevalence and Patterns of Canine Impaction Among Orthodontic Patients in Brunei Muara: A Cross-Sectional Study

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Abstract

Background

Canine impaction has been a widely known dental anomaly. This study assessed the prevalence and patterns of canine impaction in orthodontic clinics in the Brunei Muara district.

Methods

A cross-sectional study was conducted at the National Dental Centre in Brunei Darussalam. The data of patients registered to the waiting list from 1st January of 2022 to the 31st December of 2024 were extracted through the Brunei Darussalam Healthcare Information and Management System (Bru-HIMS). Data analysis was done using RStudio to determine the association between study variables and outcomes.

Results

The prevalence of canine impaction in the orthodontic unit in Brunei Muara was 5.3% with a 95% Confidence Interval (CI) of 3.4% to 8.0%. The incidence of upper left canine impaction was greater than upper right canine impaction. No significant difference was found between canine impaction and age, gender, ethnicity and malocclusion. However, a significant relationship was found in the distribution of canine impaction subtypes based on their anatomical position.

Conclusions

Understanding the prevalence of canine impaction is necessary to improve the quality of orthodontic treatment. A larger-scale study is recommended to attain a more comprehensive evaluation.

Background

Tooth impaction is a condition in which a tooth remains embedded within the alveolar bone after its expected eruption period [1]. Accordingly, permanent maxillary canine impactions are the second most common impacted tooth following maxillary third molar impactions [2]. Impacted canines posed significant challenges as they could impair mechanical function, diminish facial aesthetics and deteriorate an individual's mental well-being. Furthermore, it was found that impacted canines could also cause root resorption on the adjacent permanent lateral incisor if the patient did not receive orthodontic treatments at the appropriate time [3]. Dental professionals, therefore, must be able to diagnose and develop proper treatment plans that best serve the needs of patients with impacted canines [4].

The aetiology of canine impactions had been studied by many researchers. Hence, the causes of permanent canine impaction were classified as either local or general [5]. For instance, endocrine deficiencies, febrile diseases and irradiation were some generalised factors that could lead to the occurrence of upper canine impactions. On the contrary, localised factors such as difference in tooth size-arch length, extended retention or premature loss of primary canines, abnormal tooth bud position and alveolar cleft were typically the most common causes of impacted canines [6]. Additionally, the incidence of maxillary canine impaction was reported to be lower among individuals with missing adjacent lateral incisors [7]. This suggested that permanent maxillary canine eruption may be influenced by changes to its surrounding structure. Moreover, some studies reported a significant association between canine impaction and malocclusion [8, 9]. However, other studies also found no significant difference between the two [10, 11]. Therefore, it can be inferred that the aetiology of canine impactions is multifactorial.

Notably, the prevalence of canine impaction varies across different population. For example, Saudi Arabia reported a prevalence of 1.44% to 4% [12, 13]. In India, the prevalence of impacted canines was 1.38% to 4.9% [14, 15]. Remarkably, one study acquired a relatively high prevalence of canine impaction in Iran which was 16.2% [11].

In addition, a number of studies indicated a significant difference between canine impaction and gender. Some studies found that the incidence of canine impaction was greater in males compared to females [12, 13]. However, several other studies reported opposing findings in which the incidence was higher in females [8, 16]. Yet, no significant difference between gender and canine impaction was also observed in a number of studies [14, 15, 17, 18]. Furthermore, considerable association was reported between age and impacted canines [12, 13]. Hence, it is worth investigating the prevalence of canine impaction as well as its relation with various demographic factors.

Besides prevalence, evaluating the patterns of canine impaction provides valuable insights as well. In orthodontics, two classifications were frequently used to categorise canine impactions into several subtypes which are Yamamoto's classification and Ericson and Kurol's classification [3, 19]. Yamamoto's classification established several subtypes of canine impaction based on the angle of the canine in relation to the occlusal plane. Different subtypes of canine impaction indicated specific developmental failure in the formation of the tooth germ of the canine as seen in Fig. 1 [19]. On the other hand, Ericson and Kurol utilised their classification to predict the outcome of permanent canine eruption following surgical treatment. Subsequently, it was found that the chance of successfully normalising the permanent canine's eruption path depends on the initial position of the impacted canine prior to deciduous canine extraction [3]. Therefore, investigating the patterns and classifying canine impactions within the study population would offer useful data for the orthodontic unit in Brunei Darussalam.

In addition, no previous study has been conducted on the prevalence and patterns of canine impaction in Brunei Darussalam. As such, data and results obtained from this research allowed us to enhance our knowledge and understanding on the characteristics of canine impaction in a sample across the Brunei

Muara district. Consequently, the data can be utilized to develop effective interventions and improve the management of individuals with canine impaction within orthodontic units across Brunei Darussalam.

The objectives of this study:

1. To estimate the prevalence and types of canine impaction among referrals to the orthodontic unit in Brunei Muara.
2. To investigate the relationship between types of canine impaction and demographic factors
3. To determine the distribution of subtypes of canine impaction based on the anatomical position of the canine.
4. To assess the association between canine impaction and malocclusion classifications including skeletal base, incisor relationship and canine relationship.

Methods

Study Design

A cross-sectional study design was implemented for the current study. It allowed the study to obtain relevant data regarding the prevalence of canine impaction during the defined time period.

Population and Sample

Target Population

The study collated pertinent patients who were registered to the waiting list for orthodontic treatment from 1st January 2022 to 31st December 2024 in the National Dental Centre.

Source Population

Referrals to the orthodontic unit in the National Dental Centre were collected through the Brunei Darussalam Healthcare Information and Management System (Bru-HIMS). The system was accessed through one of the computers at the National Dental Centre.

Inclusion and Exclusion Criteria

The inclusion 16 criteria were dentate patients between the age of 14–70 years. Since the normal age of canine eruption is typically between 9 and 12 years, the minimum age criteria ensured that an unerupted canine can truly be defined as impacted. The exclusion criteria were patients with primary dentition, any diseases, trauma or genetic disorders that may affect the normal development of permanent dentition. Patients with orthopantomograms of poor quality or missing relevant data in their clinical notes were also excluded from the study.

Sampling and Sample Size

All eligible cases were taken during the study period without sampling.

Data Collection Procedure

Ethics approval

from Institute of Health Science and Ministry of Health Research Ethics Committee (IHS-MHREC) was obtained. Permission to conduct the research were also obtained from the Biomedical and Research Ethics Unit (BREU) - Ministry of Health and Director of Dental Services. Once permission to proceed with the study was granted, the principal research approached the gatekeeper (clinical supervisor) for the clinical notes of the referrals including their orthopantomograms. Under the supervision of the gatekeeper, the principal researcher was given access to Bru-HIMS through the gatekeeper's account using one of the computers at the National Dental Centre. The gatekeeper also ensured that access given was only limited to patients' clinical notes and orthopantomograms. The principal researcher then scrutinized and collated referrals who fit the inclusion and exclusion criteria. Patients' gender, age, ethnicity, canine impaction (if any) and malocclusion status including skeletal base, incisor relationship and canine relationship were the extracted from Bru-HIMS by the principal researcher. The data extracted were then transferred and organised in a dedicated Excel sheet. To preserve anonymity, patient information such as name, IC number and Bru-HIMS number was not extracted, and each patient was given their own unique identification number.

Research Instruments

A classification system reported by Yamamoto was used as an instrument to classify canine impaction into seven different subtypes [19]. The system classifies different canine impaction according to the angle of the tooth axis relative to the occlusal plane (Fig. 1).

Another classification system of canine impaction by Ericson and Kurol was also used in this study [3]. It was used to identify impacted canines into five subtypes based on their position relative to the lateral and central incisors in the same quadrant (Fig. 2).

Data Analysis

Data extracted was analysed using RStudio 2023.12.0 + 369 for windows. Descriptive statistics and normal estimation method using 95% confidence interval was conducted to estimate the types of canine impaction among the referrals.

Chi-square test for independence was another statistical analysis used to assess the association between canine impaction and demographic variables including genders, ethnicities and age groups. It

was also performed to analyse the distribution of canine impaction subtypes. Additionally, the correlation between impacted canines and malocclusion was also investigated through this analysis. All statistical tests were two-sided and p-value less than 0.05 was considered as significant.

Ethical Consideration

Ethics approval

was obtained from the Institute of Health Sciences and Ministry of Health Research Ethics Committee (IHS-MHREC), Ministry of Health, Brunei Darussalam. Permission was also obtained from the Biomedical and Research Ethics Unit (BREU), Ministry of Health, and the Director of Dental Services before the study commenced. The study was conducted in accordance with the principles of the Declaration of Helsinki. Informed consent from patients was not required because the study involved no direct contact with patients and used data available in the Brunei Darussalam Healthcare Information and Management System (Bru-HIMS). Patient confidentiality was maintained throughout the data extraction process. Patients' names, IC numbers and Bru-HIMS numbers were not extracted, and each referral was assigned a unique identification number. Data were stored in a password-protected computer accessible only to the principal researcher and supervisors. The data collected will be given ownership to the Ministry of Health and UBD, and data files will be deleted five years after completion of the study.

Patient confidentiality was another important ethical consideration during data extraction process. Referrals' personal information such as name, IC number and Bru-HIMS number was not extracted in order to protect their identity. Additionally, each referral was given their own unique identification number to further ensure anonymity. To guarantee data security, data extracted was stored in a dedicated Excel sheet in a password-protected computer only accessible by the principal researcher and supervisors. The data collected will be given ownership to the Ministry of Health and UBD. Data files will be deleted five years after completion of study.

Results

From Table 1, the study collected 419 referrals to the orthodontic unit. The study population consisted of 120 (28.6%) males and 299 females (71.4%). Additionally, 374 (89.2%) patients were Malay, 41 (9.8%) were Chinese and 4 (1.0%) patients were neither Malay nor Chinese. The age distribution was skewed to the right with a median of 18 an interquartile range (IQR) of 7.

Table 1 Sociodemographic characteristics of study population (419 referrals)

Variable	<i>n</i> (%)	Median (IQR)
Age (year)	-	18 (7) ^a
Gender		
Male	120 (28.6)	
Female	299 (71.4)	
Ethnicity		
Malay	374 (89.2)	
Chinese	41 (9.8)	
Others	4 (1.0)	

SD = Standard Deviation; IQR = Interquartile range;

^a The distribution was skewed to the right

Out of 419 referrals, 22 (5.3%) patients reported with at least one canine impaction with a 95% Confidence Interval (CI) of 3.4% to 8.0% as shown in Table 2. Canine impaction existed in various types which were based on the quadrant they occur. All canine impaction cases occurred in the maxillary arch and were unilateral. Subsequently, 8 (1.9%) patients with a 95% CI of 0.9% to 3.9% had an impaction on the upper right canine (URC). Upper left canine (ULC) impactions were present in 14 (3.3%) cases with a 95% CI of 1.9% to 5.7%.

Table 2 Estimated prevalence and types of canine impaction among study population (419 referrals)

Variable	<i>n</i> (%)	95% CI ^a
Types of canine impaction		
No canine impaction	397 (95)	(92.0, 96.6)
At least one canine impaction	22 (5.3)	(3.40, 7.96)
Impaction on upper right canine	8 (1.9)	(0.89, 3.88)
Impaction on upper left canine	14 (3.3)	(1.91, 5.68)

^a CI = Confidence Interval

Table 3 highlighted the pattern of canine impaction across three demographic factors. Accordingly, canine impactions cases found were made up of 5 males and 17 females. Furthermore, all 8 cases of URC impaction patients were females. On the other hand, ULC impaction patients consisted of 9 (64%)

females and 5 (36%) males. However, the study had found no significant correlation between maxillary permanent canine impactions and gender.

In terms of ethnicity, URC impaction cases included 7 (88%) Malay patients and 1 (13%) Chinese patient. For ULC impactions cases, 12 (86%) were Malay and 2 (14%) were Chinese. However, no significant difference was reported between canine impaction and ethnicity. Additionally, maxillary canine impaction was most prevalent among patients aged 14 to 19 years. Similar to the other demographic factors, no significant association was found between the proportion of maxillary impacted canines and age groups.

Table 3 Types of canine impaction among demographic factors (419 referrals)

Variable	<i>n</i> (%)	No impaction <i>n</i> (%)	URC <i>n</i> (%)	ULC <i>n</i> (%)	<i>P</i> value^a
Gender					0.166
Male	120 (29%)	115 (29%)	0 (0%)	5 (36%)	
Female	299 (71%)	282 (71%)	8 (100%)	9 (64%)	
Ethnicity					0.671
Malay	374 (89%)	355 (89%)	7 (88%)	12 (86%)	
Chinese	41 (9.8%)	38 (9.6%)	1 (13%)	2 (14%)	
Others	4 (1.0%)	4 (1.0%)	0 (0%)	0 (0%)	
Age group					0.625
14-19	237 (57%)	222 (56%)	5 (63%)	10 (71%)	
20-29	155 (37%)	149 (38%)	2 (25%)	4 (29%)	
≥30	27 (6.4%)	26 (6.5%)	1 (13%)	0 (0%)	

^a Fisher's exact test

Interestingly, two canine impaction cases were unclassifiable (Fig. 3). This was due to their anatomical positions and angulations which did not fit any of the criteria in Yamamoto and EK classifications. Moreover, bilateral transposition between permanent maxillary canines and first premolars was observed in both cases.

Table 4 illustrated the distribution of subtypes of canine impaction. The subtypes of canine impaction were based on their tooth axis angle in relation to the occlusal as well as the position of the tip of the canine. According to Yamamoto's canine impaction classification, Type II was the most prevalent subtype of canine impaction which was found in 11 (55%) out of the total impacted canine cases. Few

variations were seen in the distribution of canine impaction subtypes in the upper right quadrant as there were only two subtypes (Type I and Type II) reported. On the contrary, ULC impaction cases presented with more variety in their distribution as four subtypes (Type I, II, IV and VII) were identified in this quadrant. Furthermore, Type III, V and VI were not found among all canine impaction cases. However, no significant correlation was established in the subtype distribution based on Yamamoto's classification.

In contrast to Yamamoto's classification, a significant difference was found ($p < 0.05$) in the distribution of canine impaction subtype through Ericson and Kurol's classification. Sector 1 had the highest proportion of impacted canine patients with 9 (45%) cases. Alternatively, Sector 4 had the lowest with only 1 (5%) case of canine impaction which occurred in the upper right quadrant. Although no URC impactions were categorised in Sector 5, the distribution of subtypes was more evenly spread compared to the distribution in ULC impactions. For ULC impactions, 7 (58%) cases were identified in Sector 1, only one (8.3%) case in Sector 3 and four (33%) cases in Sector 5. However, no ULC impactions were classified in Sector 2 and Sector 4. Representative radiographic examples of these classifications are shown in Fig. 4.

Table 4 Distribution of subtypes of canine impaction (20 canine impaction cases).

Variable	<i>n</i> (%)	URC <i>n</i> (%)	ULC <i>n</i> (%)	<i>P</i> value^a
Yamamoto's subtypes				0.332
Type I	5 (25)	3 (38)	2 (17)	
Type II	11 (55)	5 (63)	6 (50)	
Type III	0 (0)	0 (0)	0 (0)	
Type IV	3 (15)	0 (0)	3 (25)	
Type V	0 (0)	0 (0)	0 (0)	
Type VI	0 (0)	0 (0)	0 (0)	
Type VII	1 (5.0)	0 (0)	1 (8.3)	
Ericson & Kurol's subtypes				0.016
Sector 1	9 (45)	2 (25)	7 (58)	
Sector 2	3 (15)	3 (38)	0 (0)	
Sector 3	3 (15)	2 (25)	1 (8.3)	
Sector 4	1 (5.0)	1 (13)	0 (0)	
Sector 5	4 (20)	0 (0)	4 (33)	

^a Fisher's exact test

Table 5 showed the proportion of canine impaction in relation to patients' skeletal base and incisor relationship. In this study, 5 (46%) patients presented with skeletal base III make up the lowest proportion of maxillary impacted canine cases. Nonetheless, no significant relationship was found between the patient's skeletal profile and occurrence of canine impaction in this study.

Patients with Class II Division 1 incisor relationship presented with the highest proportion among the study population with 145 (35%) of total cases. Conversely, the incisor relationship with the lowest proportion were Class II intermediate and Class II indefinite with both having two cases each. Similarly, no significant difference was reported between canine impaction and incisor relationship.

Table 5 Canine impaction in relation to skeletal base and incisor relationship (419 referrals)

Variable	<i>n</i> (%)	No impaction <i>n</i> (%)	URC <i>n</i> (%)	ULC <i>n</i> (%)	<i>P</i> value ^a
Skeletal base					0.922
Class I	154 (37)	145 (37)	3 (38)	6 (43)	
Class II	184 (44)	176 (44)	3 (38)	5 (36)	
Class III	81 (19)	76 (19)	2 (25)	3 (21)	
Incisor relationship					0.689
Class I	109 (26)	101 (25)	4 (50)	4 (29)	
Class II Division 1	145 (35)	140 (35)	2 (25)	3 (21)	
Class II Division 2	31 (7.4)	29 (7.3)	0 (0)	2 (14)	
Class II Intermediate	2 (0.5)	2 (0.5)	0 (0)	0 (0)	
Class II Indefinite	2 (0.5)	2 (0.5)	0 (0)	0 (0)	
Class III	130 (31)	123 (31)	2 (25)	5 (36)	

^a Fisher's exact test

Table 6 and Table 7 highlighted the relationship between the unilateral upper impacted canine and the canine relationship of the opposite canine. From Table 6, 154 (37%) patients with Class II ½ unit canine relationship on the left-hand side (LHS) presented with the greatest proportion among the study population. Furthermore, this relationship class was exhibited in half of URC impaction patients. No URC

impaction patients reported with Class II full unit and Class III full unit relationships on the LHS. Nevertheless, no significant difference was found between URC impaction and LHS canine relationship. Similarly, Table 7 revealed that Class II ½ unit canine relationship on the right-hand side (RHS) had the highest proportion of patients with 139 (33%) cases. Moreover, the majority of ULC impaction patients had Class III ½ unit RHS canine relationship. Likewise, there were no significant difference between ULC impaction and RHS canine relationship.

Table 6 Canine relationship of the left-hand side (LHS) in relation to URC impaction (419 referrals)

Variable	n (%)	No impaction n (%)	URC n (%)	P value^a
LHS canine relationship				0.594
N/A	20 (4.8)	20 (4.9)	0 (0)	
Class I	69 (16)	66 (16)	3 (38)	
Class II ½ unit	154 (37)	150 (36)	4 (50)	
Class II full unit	50 (12)	50 (12)	0 (0)	
Class III ½ unit	104 (25)	103 (25)	1 (13)	
Class III full unit	22 (5.3)	22 (5.4)	0 (0)	

^a Fisher's exact test

Table 7 Canine relationship of the right-hand side (RHS) in relation to ULC impaction (419 referrals)

Variable	n (%)	No impaction n (%)	ULC n (%)	P value^a
RHS canine relationship				0.645
N/A	14 (3.3)	14 (3.5)	0 (0)	
Class I	85 (20)	82 (20)	3 (21)	
Class II ½ unit	139 (33)	134 (33)	5 (36)	
Class II full unit	52 (12)	52 (13)	0 (0)	
Class III ½ unit	111 (26)	105 (26)	6 (43)	
Class III full unit	18 (4.3)	18 (4.4)	0 (0)	

Discussion

Understanding the prevalence of canine impaction is important for developing effective interventions, treatments and management. This study reported a 5.3% prevalence of canine impaction in the orthodontic unit in Brunei Muara. The prevalence attained was relatively consistent with other similar studies conducted in Egypt, India, Saudi Arabia, Portugal and Cyprus [8, 12–18]. In terms of the types of canine impaction, the current study showed that maxillary canine impaction was more prevalent on the left quadrant than on the right quadrant which was contradictory to the findings in several other studies [15, 18, 19].

Additionally, since no mandibular and bilateral canine impactions were reported among the study population, this further emphasised the rarity of these types of canine impactions as reported by previous studies [11, 16, 17]. Furthermore, this study reported no significant difference between canine impaction and demographic factors including gender, ethnicity and age. Insignificant difference between the two variables was also evident in other studies [14, 15, 17, 18].

The utilisation of both classifications could assist orthodontists in creating optimal treatment plans for specific subtypes of canine impaction cases [3, 19]. The study conducted by Yamamoto found that the most frequent canine impaction subtype was Type I. In contrast, the current study had found Type II to be the most common. Accordingly, Type II canine impaction subtype often cause resorption of the adjacent lateral incisor root in which extraction of the lateral incisor might be necessary to resolve the impaction [19]. Hence, orthodontists must be proficient in various surgical treatments for different subtypes of canine impaction. Nevertheless, the study found no significant difference in the distribution of canine impaction subtypes through this classification.

On the other hand, the study reported a significant difference in the distribution of canine impaction subtypes through Ericson and Kurol's classification. The present study demonstrated that the highest proportion of canine impaction cases were classified in Sector 1. This sector was found to have shown the fastest canine position improvement following primary canine extraction. However, this outcome was only applicable to patients aged 10–13 years [3]. Consequently, referrals of that age presenting with impacted canines were recommended to undergo deciduous canine extraction. Thus, both classifications emphasised early diagnosis of canine impaction and identification of its initial position as crucial factors in determining the success of surgical treatment.

Remarkably, two reported cases of canine impaction were unclassifiable as their anatomical positions and angulations did not fit any of the criteria in Yamamoto and Ericson and Kurol's classifications (Fig. 3). The two impacted canines were positioned in between the permanent maxillary first and second premolars which was beyond the defined parameters of Yamamoto's classification. In Ericson and

Kurol's classification system, both canine tips were located within an undefined area distal to Sector 1 which was around the first premolar region.

Therefore, it could be assumed that the two cases could not be categorised under either classification due to the observed transposition of the maxillary canine and first premolar. Tooth transposition refers to a dental anomaly in which positional changes occurred between two adjacent teeth with a reported prevalence of 0.33% [20, 21]. Furthermore, bilateral transposition between permanent maxillary canines and first premolars was observed in both cases which was less common compared to its unilateral counterpart [22]. Yet, the association between canine impaction and transposition had not been explored thoroughly.

Similar to another study, no significant association was found between canine impaction and malocclusion in this study [11]. Conversely, another study presented conflicting results as a significant association was established and suggested that malocclusion status could be used as a predictor for canine impaction [8]. Since the present study reported an opposing result, it indicated that the proposed correlation was inapplicable to the current study population.

Limitations

Several limitations have been identified in this study. Firstly, the current study only gathered data of referrals to the orthodontic unit. This implied that people with impacted canines who were not referred to the unit were excluded from this study. Thus, the study population was not an accurate representative of the whole Brunei Muara population. Furthermore, this would affect the accuracy of the results regarding the patterns of canine impaction within the study population.

Recommendations

A larger scale study is recommended in order to attain a more comprehensive evaluation of the prevalence and patterns of canine impaction. Future studies should assess the prevalence across the whole population of Brunei Darussalam along with the aetiology of canine impactions. In addition, investigating the association between canine impaction and other dental anomalies such as transposition may provide a valuable insight.

Conclusion

The prevalence of canine impaction among referrals to the orthodontic unit in Brunei Muara in this study was 5.3% with a 95% Confidence Interval of 3.4% to 8.0%. Impaction of the upper left canine was more prevalent than the upper right canine. No significant association was reported between canine impaction and demographic factors including gender, ethnicity and age. Likewise, the correlation between canine impaction and malocclusion was not significantly different. A significant relationship was only found in the distribution of canine impaction subtypes based on Ericson and Kurol's classification system.

Classifying impacted canines may help orthodontists plan effective treatments for specific canine impaction subtypes.

Abbreviations

URC

Upper right canine

ULC

Upper left canine

CI

Confidence interval

SD

Standard deviation

IQR

Interquartile range

n

Number

Declarations

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Conflicts of interest/Competing interests

The author declares no competing interests.

Ethics approval and consent to participate

Ethics approval was obtained from the Institute of Health Sciences and Ministry of Health Research Ethics Committee (IHS-MHREC), Ministry of Health, Brunei Darussalam. Permission was also obtained from the Biomedical and Research Ethics Unit (BREU), Ministry of Health, and the Director of Dental Services. The study was conducted in accordance with the principles of the Declaration of Helsinki.

Informed consent was not required because the study involved no direct contact with patients and used data available in Bru-HIMS.

Availability of data and material

We extracted and analysed retrospective patient data from the Brunei Darussalam Healthcare Information and Management System (Bru-HIMS), including demographic characteristics, canine impaction status, impaction classifications, and malocclusion variables. The data are not publicly available because they are derived from patient clinical records and are subject to confidentiality and institutional restrictions. The data collected will be given ownership to the Ministry of Health and UBD, and data files will be deleted five years after completion of the study. Access to the data may be considered upon reasonable request, subject to approval from the relevant authorities.

Consent for publication

Not applicable. The manuscript does not contain information that identifies individual patients.

Authors' contributions

AQA contributed to the conception and design of the study, data collection, data analysis, interpretation of the results, and drafting of the manuscript. UKU conceptualised, designed and supervised the study including facilitating access to extraction of clinical data. HAR contributed to study supervision, methodological guidance, and critical review of the manuscript. LN contributed to the statistical analysis, interpretation of the results, and critical review of the manuscript. JSD contributed to study supervision, interpretation of the findings, funding acquisition for publication and critical revision and submission of the manuscript. All authors read and approved the final manuscript.

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Figures

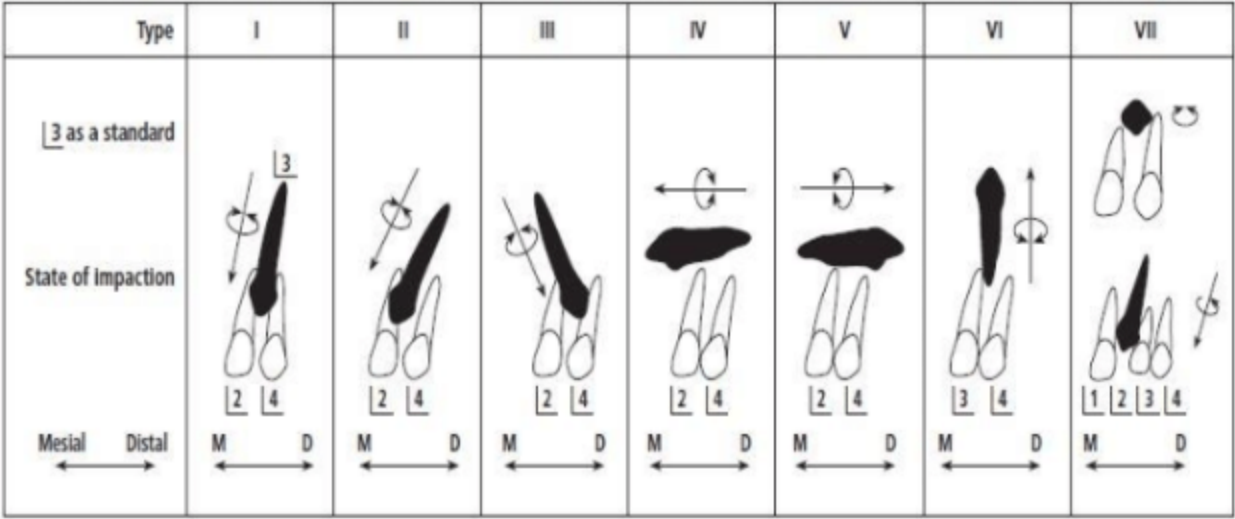


Figure 1

Classification of canine impaction by Yamamoto

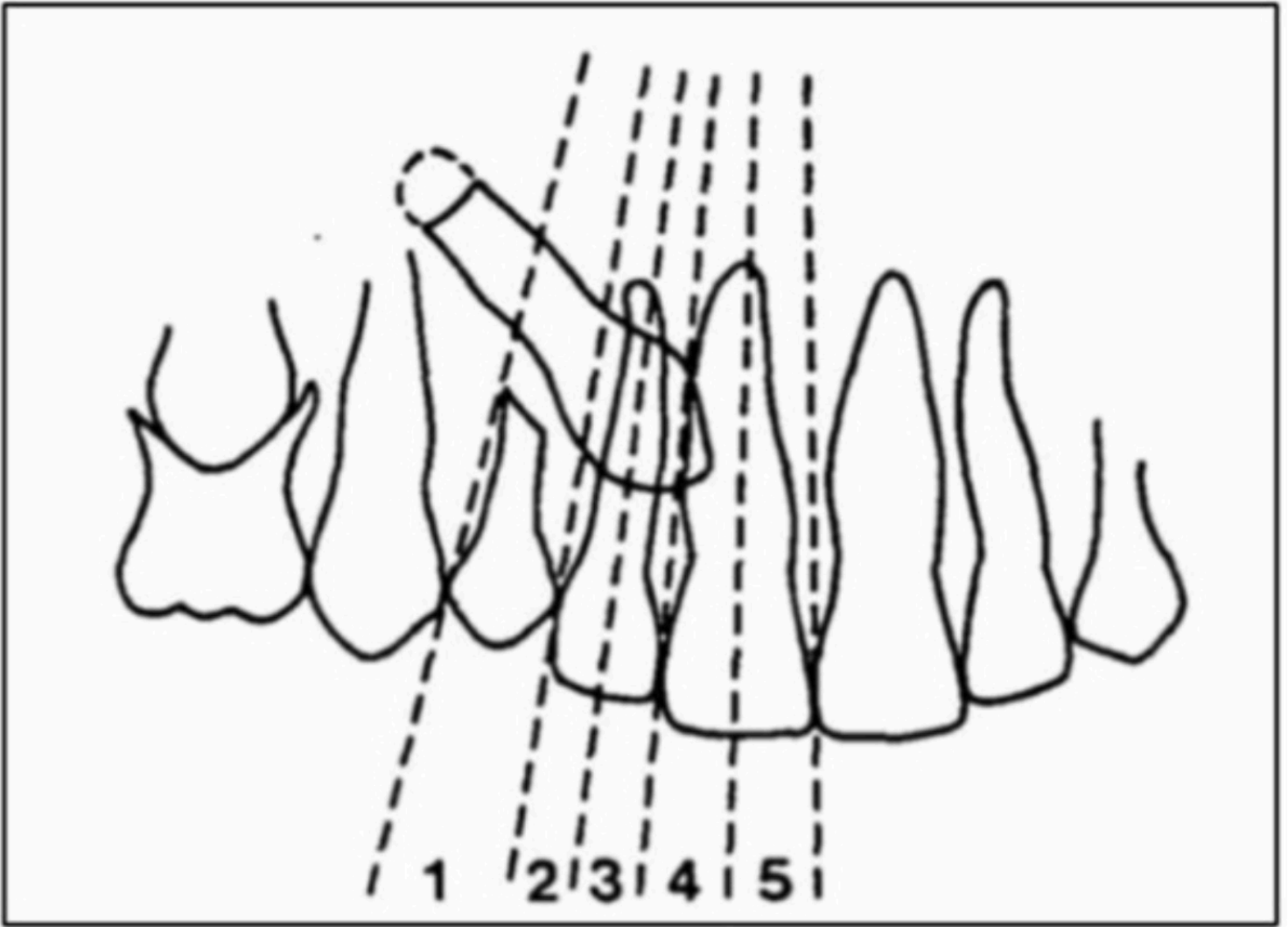


Figure 2

Canine impaction classification by Ericson and Kurol

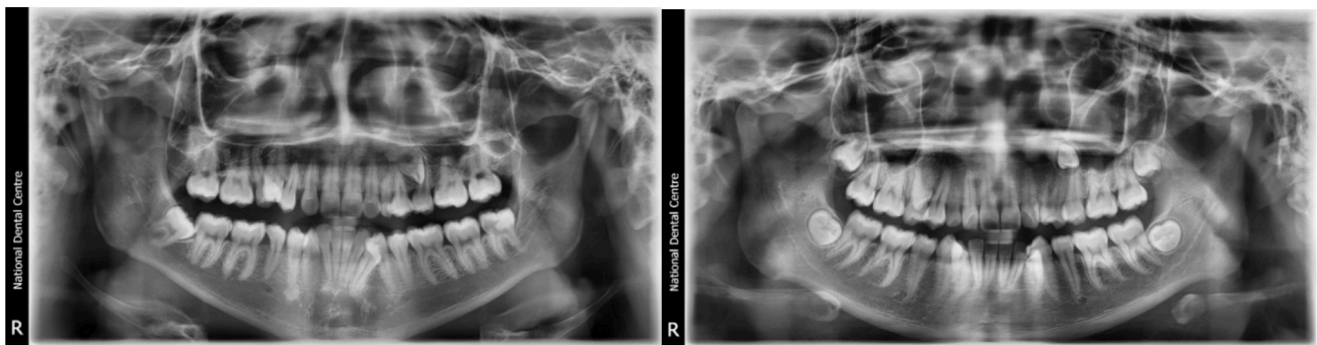


Figure 3

Two ULC impaction cases with bilateral transposition of upper canines and first premolars.

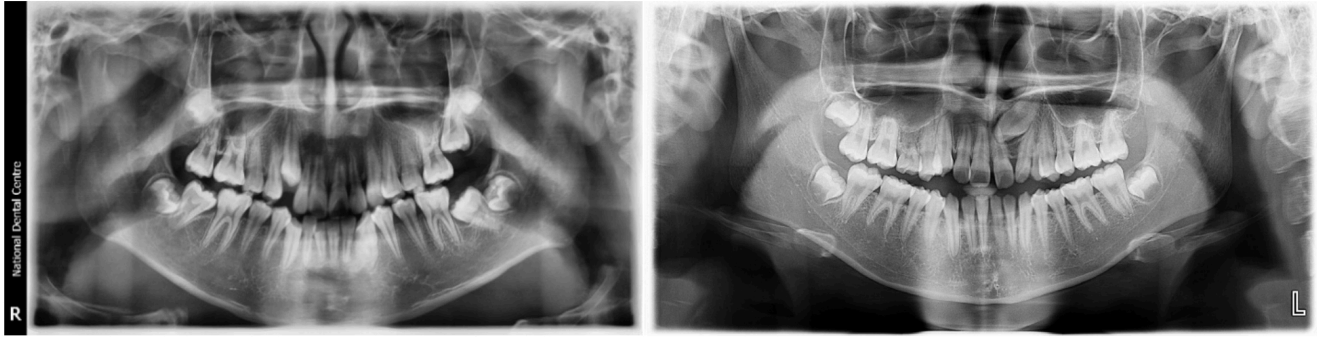


Figure 4

(Left) Type I URC impaction within Sector 1. (Right) Type II Sector 5 ULC impaction.