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Review Article

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Impacted Canines Classification Systems Among Orthodontic Patients

Dr. Yahya H. Y. Alfarra [1,*] , **Dr. Tahir Yusuf Noorani** [2] , **Dr. Jawaad Ahmed Asif** [3] , **Assoc. Prof. Wan Muhamad Amir Wan Ahmad** [4] , **and Prof. Zainul Ahmad Rajion** [5]

[1] *Orthodontic Unit, School of Dental Sciences, Health Campus, Universiti Sains Malaysia, Malaysia*
[2] *Conservative Dentistry Unit, School of Dental Sciences, Health Campus, Universiti Sains Malaysia, Malaysia*
[3] *Oral and Maxillofacial Surgery Unit, Prince Mutaib Bin Abdul Aziz Hospital, Ministry of Health, Kingdom of Saudi Arabia*
[4] *Biostatistics Unit, School of Dental Sciences, Health Campus, Universiti Sains Malaysia, Malaysia*
[5] *Department of Oral Maxillofacial Surgery and Oral Diagnosis, Kulliyyah of Dentistry, Kuantan Campus, International Islamic University Malaysia, Malaysia*

Abstract: This review covers all aspects from the viewpoint of impacted canines that were missed by some articles. Most review studies focus on the epidemiology and incidence of the disease but rarely on the detailed investigation of this therapeutic disorder; therefore, appropriate awareness of canine impaction diagnosis and management is critical prior to any orthosurgical treatment procedures. Hence, it is crucial to emphasize the means of proper diagnosis and interception of this clinical condition. This study aimed to compare and review the various diagnostic methods used to identify canine impaction, its advantages, shortcomings, research, and clinical implications to guide the evaluation and management of cases in general dental practice. Based on the current literature, the epidemiology of canine impaction, diagnosis, classification systems, and surgical options for exposing impacted canines are discussed. To determine the anatomical position of impacted canines, a thorough clinical examination and appropriate diagnostic imaging should be performed. The surgical method for exposing impacted canines should consider the tooth's anatomical position in regard to the alveolar ridge and the amount of keratinized mucosa/gingiva. The article concludes that displacement and non-eruption of impacted canines can be managed by administering an accurate and adequate diagnosis of canine impaction, proper investigation of tooth position, length, direction, and related structures, selecting the appropriate management approach, and also reducing the biomechanics involved during canine retraction using fixed orthodontic appliances when they are impacted, and thus can restrict the risk of surgical trauma on the adjacent hard and soft tissues in the patients. This article may suggest that 3D imaging is required to assist clinicians in developing a successful treatment plan for detecting impaction and the surrounding structures . CPD / Clinical Relevance: Canine impactions are frequent during routine examinations. Appropriate identification, investigation, and, if necessary, referral are crucial to the outcome of treatment success.

Keywords: Canines, Impaction, Orthodontics, Patients, 3D, Classification

* Corresponding Author

Dr. Yahya H. Y. Alfarra, Orthodontic Unit, School of Dental Sciences, Health Campus, Universiti Sains Malaysia, Malaysia.
E-mail: dr.yalfarra@yahoo.ca

1. INTRODUCTION

Impaction is the failure of a tooth to erupt at its proper location in the dental arch during its normal growth period.[1] After the third molar, the permanent maxillary canine is the most commonly impacted tooth.[2,3] The permanent canines, the cornerstone of the dental arches, are considered essential and strategic in the dental arch, both esthetically and functionally. It is located in the corner of the dental arch, forming the canine eminence to support the upper lip and the alar base, both of which are required for smile esthetics.[4] Functionally known as 'cuspid protection', it supports the dentition, significantly contributing to its disarticulation in lateral movements and masticatory load, as well as contributing to functional occlusion and directing the jaw into the proper orientation.[5] It also aids in the biting and tearing of food. Along with its root volume and length, it is one of the most important outstanding abutments for prosthetic replacement of other maxillary teeth.[6] Consequently, impacted canines pose numerous challenges for clinicians since it compromises tooth exposure as well as its movement for esthetical and functional outcomes. Displacement and non-eruption are critical consequences of ectopic eruption and impaction in these teeth with significant functional and cosmetic significance.[7] Complications may occur as a result of tooth impaction, including esthetic and phonetic compromises, loss of arch length, and associated pain.[8] The optimum facial harmonization is thought to be the outcome of well-defined dentofacial features.[9] Every clinician aspires to deliver the best and most exciting treatment outcomes for treating orthodontic cases. To achieve the proper outcomes, the condition must be properly diagnosed. Therefore, to reach the desired treatment goals, complete knowledge of impacted canines' morphology with a comprehensive understanding of the surrounding anatomical structures' complexity is particularly crucial in clinical practice.[10,11] Furthermore, a thorough knowledge of the impacted canines' classification is essential for documenting and facilitating communication among practitioners. While there are different impacted canines' classification systems, there are many disadvantages that come along with each system. While some are descriptive, others are concise but do not provide sufficient information. Apart from canine morphology, a practitioner should be familiar with potential canine morphologic variations, such as an impacted canine erupting high in the alveolar ridge or the sulcus overlying palatal mucosa and/or bone, which results in impaction later.[12,13] Two-dimensional (2D) radiographs have traditionally been used to detect impacted canines in various populations, including Italian,[14] Swedish,[15] and Turkish.[16] However, employing 2D radiography methods to find impacted canines has significant limitations, including anatomical structural distortion and superimposition.[17] Furthermore, the KPG index was not verified as a reliable method of evaluating treatment time and difficulty of surgical treatment for impacted canines in a study by Kau et al.[18] Another drawback of the study by Kau et al.[18] was the small sample size. Further verification studies should include larger sample sizes and compare differing mechanics. This review was developed to analyze various classification systems and diagnostic methods for impacted canines and discuss their advantages, shortcomings, and research implications.

2. CANINE IMPACTION DEVELOPMENT, ETIOLOGY, AND PREVALENCE

Canine development begins lateral to the piriform fossa, high in the maxilla, around four to five months of age, and has the longest eruption route at 22 mm.[19] The crown begins to calcify at one year and is completed in six to seven years, including the roots of the deciduous first molar. Following that, it migrates downwards and forward to lie mesial and buccal to the apex of the deciduous canine, then progresses downwards along the distal half of the upper lateral incisor's root.[20] According to Piya et al.,[6] before the crown of the tooth, is calcified, the canine remains high in the maxilla, often above the root of the lateral incisor. It subsequently erupts over the distal surface of the lateral incisor, closing any physiological diastema that may exist as the canine erupts into position. It leads to midline spacing if not self-corrected. This is referred to as the ugly duckling stage.[6] Maxillary canines often arise between 11 and 12 years.[12] The mandibular canines begin to calcify at the age of four months, and the enamel of the crown is fully grown by the age of seven years. The permanent mandibular canines erupt around 9 to 10 years, with females erupting earlier than males. Permanent canine teeth usually appear between the ages of 9.3 and 13.1 years.[21] Canines have a high rate of impaction because they take the longest time to develop, are the last tooth to form, and have the most tortuous path. They are progressing from the stage of development, lateral toward the piriform fossa, to the eventual destination of correctly functioning occlusion. During this long journey, they are frequently prone to displacements and mechanical obstructions from surrounding teeth.[22] There are several hypotheses as to why canines are impacted. However, they may be divided into two categories: genetics and guidance. According to common perception, the root of the adjacent lateral incisor acts as a guide for the canine to erupt normally into the arch.[23] However, if the next lateral incisor is congenitally absent, peg-shaped with minimum mesiodistal breadth, or deformed, there appears to be no direction for the canine to follow. As a result, the canine will not erupt. This is referred to as the guidance theory.[24] The dental abnormality of canine impaction was thought to be the result of genetic and environmental multifactorial inheritance, according to genetic theory.[25] They based their approach on the fact that palatal displaced canines occur in conjunction with other dental anomalies such as peg laterals and lateral premolar hypodontia, that they occur bilaterally, and that it is familial gender and population variance in occurrence.[11] There are several types of evidence for genetic etiology. Uribe et al.[26] discovered a relationship between canine impactions and other dental abnormalities. He discovered that impacted canines are related to genetic characteristics such as race, gender, undersized or absent lateral incisors, agenesis of adjacent teeth, aplasia, and supernumerary teeth, implying a genetic etiology. Sharma et al.[27] concluded that genetic and guidance or environmental factors, acting at various times, could lead to canine impaction. Permanent canine impaction may be caused by one or more of the following etiologies: (1) space deficiency in the dental arch, (2) disturbances in tooth eruption sequence, (3) trauma, (4) over-retained primary canine,[13] (5) premature root closure, (6) supernumerary teeth, (7) rotation of tooth buds ankylosis, (8) missing adjacent lateral incisor, (9) overlying cysts or tumors, (10) cleft lip or palate reconstructive surgery, (11) soft or bone tissue thickening.[28,29] The prevalence of impacted canine values varies significantly across ethnicities attributed to the genetic and ethnic variations[29-33] (Table 1). Considering location and gender, females are more likely than males to have permanent canine impaction.[34-37] In addition, unilateral impaction is more common than bilateral impaction.[31,32] It has been found that

palatal impaction of the permanent canine occurs more commonly than labial impaction.[10]

Table 1: Summary of the prevalence of impacted canines in different populations.					
Authors, year	Maxillary canines	Mandibular canines	Age	No. of patients with impacted canines/total no. of patients (prevalence %)	Race	Gender
Laurenziello et al.[14]	54.00	Not studied	09.00-10.00	54.00/218 (24.77 %)	Italy	Not reported
Sharmila[33]	14.00	03.00	22.00	17.00/406 (4.187 %)	India	Female (58.80 %); Male (41.20 %)
Fardi et al.[34]	109	Not reported	17.00-48.00	109/1239 (8.797 %)	Greece	Female (52.10 %); Male (47.90 %)
Altaee[30]	45.00	Not studied	15.00-36.00	45.00/975 (4.615 %)	Iraq	Female (64.40 %); Male (35.50 %)
Watted and Abu-Hussein[35]	82.00	13.00	10.50-39.50	95.00/2200 (4.318 %)	Palestine	Female (61.60 %); Male (38.40 %)
Prskalo et al.[36]	8.000	Not reported	13.00	8.000/170 (4.705 %)	Croatia	No gender specific differences
Herrera-Atoche et al.[37]	52.00	Not studied		52.00/860 (6.046 %)	Mexico	The female to male ratio was 02.06: 1

2.1   DIAGNOSIS

After the normal period of growth, the diagnosis of impacted canines is determined in subjects with a canine retained in the dental arch. Canine impaction is more difficult to diagnose in patients with developing dentition. Certain clinical conditions, such as a lack of dental arch space, have been identified as risk factors for lack of spontaneous eruption.[38] However, the position of the impacted tooth may play a factor. According to Jacoby,[39] 17 % of impacted maxillary canines are located labially, whereas approximately 85 % of palatal impacted maxillary canines have enough arch space for eruption. Increased angulation of the long axis of canine concerning the interincisor vertical midline has also been related to impaction risk.[40] There is scarce data on the prevalence of spontaneous eruption of the impacted canines in growing patients. Only information on the prevalence of spontaneous eruption of impacted incisors is available.[41] Following removal of the related supernumerary tooth/teeth, sixty-three participants with remaining permanent incisors were followed. Only half of these teeth erupted without the intervention of surgery or orthodontics. There was no relationship between spontaneous eruption and numerous potential risk variables, including patient age, number of supernumeraries, root development extent, and apical displacement of the impacted tooth. Similarly, fifty-three children had supernumerary teeth surgically removed due to incisor impaction.[42] Approximately half of the patients needed a second procedure to assist the impacted tooth in emerging using orthodontic forced eruption. These findings support the immediate application of orthodontic forces after surgical exposure because only 50 % of impacted teeth seemed to erupt without orthodontic intervention. If a spontaneous eruption does not occur, this avoids the need for a second surgical surgery.[38]

2.2   PATIENT ASSESSMENT

Careful examination of the labial and palatal tissues and measurement of the width of keratinized gingiva found in the canine area are the initial steps in the clinical evaluation of a patient with impacted canines. During the visual examination, the clinician may assess the amount of arch space available and the inclination of the lateral incisors. After that, labial and palatal palpation is used to look for the canine bud. This record provides the possible location of impacted canines as well as periodontal anatomy.[43] Mobility is examined if the primary canine is present. The existence of substantial mobility may be related to the permanent canine's eruptive movement. Periodontal parameters of adjacent teeth, such as the amount of keratinized gingiva, tooth movement, and attachment loss, should also be reported. Canine displacement is classified as buccal, palatal, or arch line (Figures 1 and 2). Canines may occasionally lay horizontally above the apices of the maxillary incisors or be displaced near the nasal cavity.[14] Based on the etiology and related occlusal features, impacted canines are usually linked to insufficient dental arch width, length, and crowding.[44,45] Crowding was identified as the primary etiological factor in canine impactions.[39] Similar evidence suggested that a lack of arch width was a local mechanical cause of impacted canines.[46]

Fig. 1: Palatal canine impaction.[47]

Fig. 2: Buccal canine impaction.[47]

2.3   RADIOGRAPHIC ASSESSMENT

The occlusal film, periapical view, panoramic view or orthopantomogram (OPG), lateral cephalogram, posteroanterior view, computed tomography (CT), and cone beam computed tomography (CBCT) are radiographic modalities used to locate impacted canines.[32] Panoramic views and lateral cephalograms provide insufficient information about the specific position, direction, and angulation of impacted canines, as well as overlapped anatomical structures, which are significant disadvantages when evaluating impacted canines.[48] Furthermore, panoramic views have other drawbacks, such as magnification, distortion, and superimposition of anatomical components.[17,32] Similarly, periapical radiographs and occlusal films have provided the most basic information about tooth development, follicle presence, and deciduous tooth resorption.[49] Posteroanterior radiographs are less useful in determining the position of impacted canines.[50] Tissue superimposition is a frequent disadvantage of the parallax approach for evaluating impacted canines.[11] These drawbacks affect the appropriate presentation, localization, and treatment planning of the impacted canines. Consequently, these examinations employing 2D radiographs did not provide enough information about the locations and directions of the impacted canines. Three-dimensional (3D) imaging, such as CT, overcomes the disadvantages of conventional radiography by determining the position of impacted canines and enhancing the root resorption detection rate. However, due to the relatively high radiation dose, which is often unjustified, the use of CT in dentistry is limited. Sir Godfrey Hounsfield developed CT in 1967, and there have been five generations of such systems since the prototype.[51] In the 1990s, CBCT was designed to overcome the superimpositions inherent in 2D imaging and give various advantages over conventional CT, including decreased radiation exposure, high resolution, short acquisition scan times, image accuracy, user-friendly software, and lower cost.[48] CBCT scans are helpful in establishing the presence of lateral incisor root resorption as well as the precise location of the impacted teeth. According to Zufia et al.,[52] the superior imaging of choice in identifying the location of impacted canines is CBCT. It is required to develop a successful treatment plan, although it can be costly.

3. METHODS

A comprehensive literature search was conducted to find published data on impacted canines classification systems published until the 1st of January 2021 on PubMed and Scopus databases using keywords, canine impaction, classification, diagnosis, and others. The following data were recorded for the literature search: the purpose of study, methods, including inclusion and exclusion criteria, number of impacted canines and participants, diagnosis (assessment of initial canine location and description used), and outcomes. Several canine impaction classification systems with modifications and supplemental types were identified and discussed in this review. Clark[53] assessed the bucco-palatal position of impacted canines based on a 2D radiograph using two periapical radiographs at different angles of x-ray tube projection in the parallax approach. The tooth is palatal in the arch if it moves in the same direction as the beam. The tooth is buccal in the arch if it moves in the opposite direction. Archer[54] classified impacted canines in two approaches based on the panoramic view. In 1988, Ericson and Kurol recognized and reported other types of impactions according to the location of impactions in relation to its long axis.[55] In 1992, Lindauer further added supplemental types to Ericson and Kurol's classification system.[56] Kau et al. identified the site of impacted maxillary canines using a 3D radiograph. The X, Y, and Z planes were used to determine the location of impacted maxillary canines, and the cusp and root tips were scored based on their deviations from the normal position. They concluded that four canines were easy, eleven were intermediate, nine were difficult, and four were extremely difficult. In terms of months, the average treatment times were as follows: simple: 11.23, moderate: 11.36, difficult: 12.76, and extremely difficult: 13.23.[18] Ghoneima et al. in 2014 divided impacted maxillary canines into distinct categories based on their location.[57]

4.   CLASSIFICATION   SYSTEMS   AND TREATMENT PLANNING

4.1   Clark's Classification.[53]

The buccal object rule, commonly known as Clark's rule, identifies the tooth's position in the parallax technique (Same Lingual Opposite Buccal (SLOB)). In this approach, two periapical radiographs are acquired at various angles of x-ray tube projection. Separate radiographs can be taken by changing the mesiodistal orientation of the x-ray beam. The apparent shift of the canine impaction between these radiographs indicates the buccolingual position. If the tooth moves in the same direction as the beam, it is palatal in the arch. If the tooth moves in the other direction, it is buccal in the arch (SLOB) (Figure 3). Periapical radiographs are used in

certain illustrations of a horizontal tube shift, and occlusal radiographs are preferred because they cover a larger area. Consequently, the tube can be moved between the two exposures, enabling the movement in the image of the impacted canines to be better observed. A part of the entire crown or root of the impacted canines is frequently not acquired on one or both periapical radiographs.[58] Jacobs described a vertical tube shift using a rotational panoramic and an occlusal radiograph. The film in front of it, the panoramic radiograph tube is positioned behind the head at a -7° angle to the occlusal plane. To facilitate interpretation of the vertical tube shift, the tube can be regarded to be in front of the head at an effective angle of +7° because the relationship between the canine image and the lateral incisor image is unchanged. The occlusal radiograph is taken at an angle of +60° to 65° to the occlusal plane, resulting in a 53° to 58° effective difference between the two films. The image of the palatal impacted canines that is further distant from the x-ray tube moves in the same direction as the tube.[58]

Fig. 3: Parallax method.[49]

4.2   Archer's Classification.[54]

Impacted canines were assessed based on the panoramic view from type I to type V as follows (Figure 4): Type I: Canine impaction placed in the palate; a) Horizontal, b) Vertical, c) Semivertical (Angulated). Type II: Canine impaction placed in the maxillary labial or buccal surface); a) Horizontal, b) Vertical, c) Semivertical (Angulated). Type III: Impacted canines situated in the labial and palatal surfaces (for example, a crown is on the palate and root of the adjacent teeth and ends on the labial or buccal surface). Type IV: Canine impaction in the alveolar process, often vertically between incisor and first bicuspids. Type V: Impacted canines located in the edentulous maxilla.
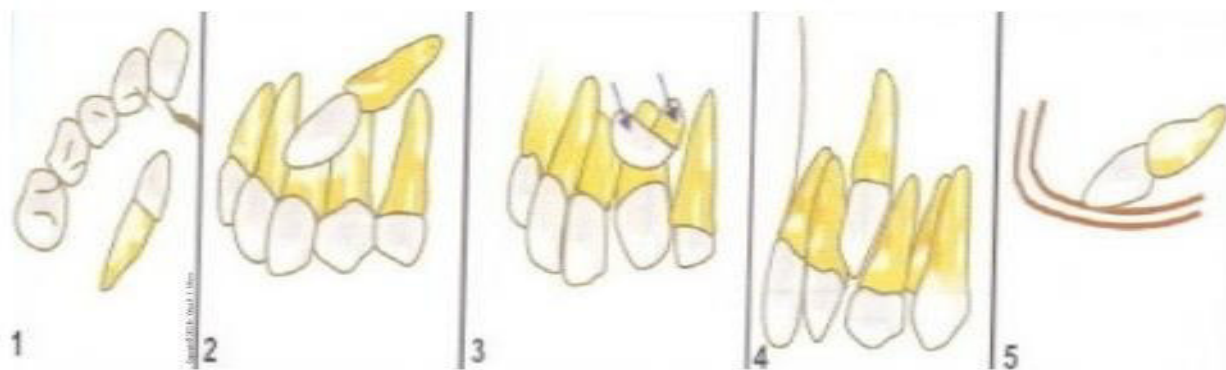

Fig. 4: Impacted maxillary canine position; (1) Palatally placed, (2) Labially placed, (3) Partly on the labial side and partly on the palatal side, (4) Canine locked between the roots of adjacent teeth, and (5) Canine in the edentulous maxilla.[23]

4.3   Ericson and Kurol's Classification.[55]

Ericson and Kurol assessed impacted canines based on the panoramic radiograph into the following types described as follows (Figure 5): Type I: If the canine's cusp tip is between the long axis of the central incisor and the line of the inter-median incisor. Type II: If the canine's cusp tip is located between the lateral and central principal axes. Type III: When the canine's cuspid height is between the first premolar and the lateral central axis.

Fig. 5: Sector description by Ericson and Kurol.[55]

4.4 Lindauer et al.[56]

Added supplementary configurations to Ericson and Kurol's Classification. The location of impacted canines was divided into four sectors: Type I: The area distal to a line tangent to the distal heights of the lateral incisor contour. Type II: The area mesial to sector I but distal to a line bisecting the mesiodistal measurement of the long axis of the lateral incisor. Type III: The region mesial to sector II but distal to a line tangent to the mesial heights of the lateral incisor contour. Type IV: All areas mesial to sector III (Figure 6).
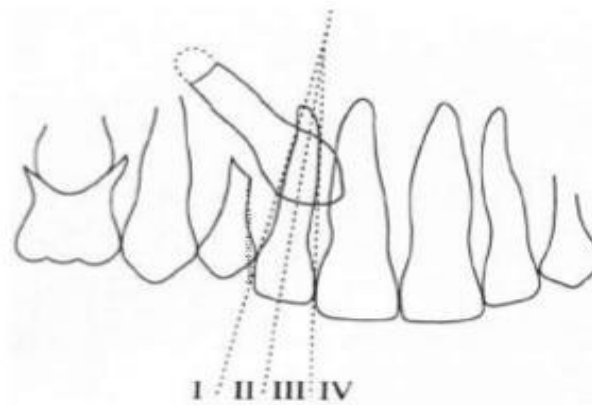

Fig. 6: Lindauer's et al. description.[56]

4.5 Kuftinec and Shapira[59]

Investigated the position of maxillary canines using a panoramic view (Figures 7, a and b). To detect the bucco-palatal site of impacted canines, the cusp tip of the maxillary canines was used. The canines are impacted labially if the tip of the canine cusp overlaps the root of the adjacent lateral incisor. When the cusp tip of the maxillary canines is medial to the long axis of the adjacent lateral incisor, palatal impaction is assumed.

Fig. 7: (a) In the orthopantomogram, the impacted maxillary left canine is nearing a posture medial to the long axis of the adjacent lateral incisor, implying palatal impaction, (b) However, the relating horizontal incisor inclination seen in the clinical image suggests labial or midcrestal impaction.[59]

4.6 Kau et al.[18]

The location of impacted maxillary canines was assessed based on their distance from the norm, with a number ranging from 0 to 5 assigned to both the cusp and root tip along the x, y, and z planes (KPG index) (Figures 8 to 11). The cumulative score is used to predict the treatment's difficulty. Every impaction was graded into four levels: easy (0-7), moderate (8-14), difficult (1-19), and extremely difficult (20+). Four canines were graded as easy, eleven as moderate, nine as difficult, and four as extremely difficult. The average treatment times associated with months were simple: 11.23, moderate: 11.36, difficult: 12.76, and extremely difficult: 13.23.
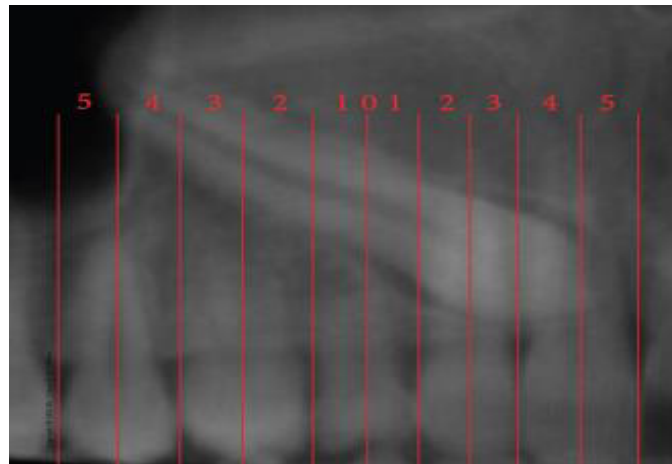

**Fig. 8: Panorex view of both cusp and root tips in mesiodistal position (x).
Cx = 5 and Rx = 5 in this example.[60]**

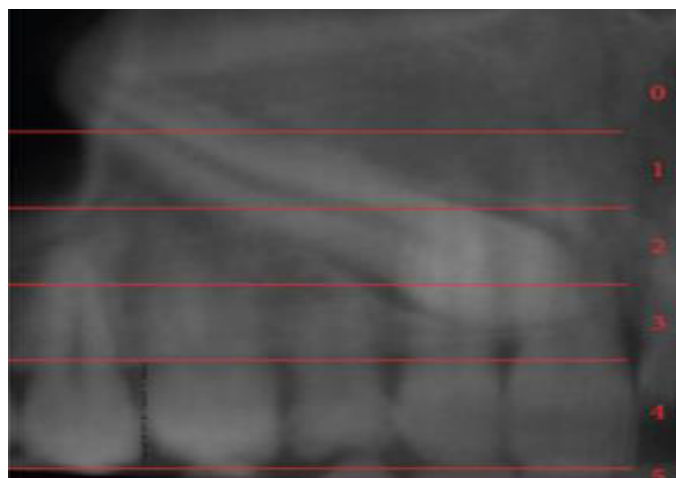**Fig. 9: Panorex view of the vertical location (y) for the cusp tip. Cy = 2 in this example. [60]**

Fig. 10: Panorex view of a root tip in vertical position (y). Ry = 0 in this case.[60]
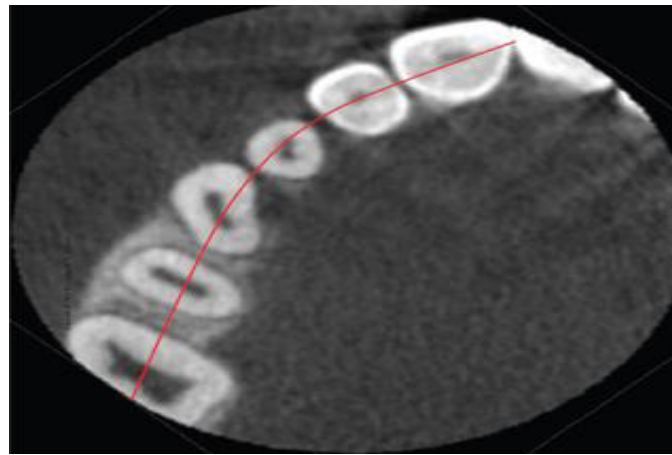
Fig. 11: Axial view of the occlusal reference arch (z). Because $Cz = 0$ and $Rz = 0$ in this example, the KPG index value is 12 (moderate difficult) (5 + 5 + 2 + 0 + 0 + 0 = 12).[60]

4.7　Ghoneima et al.[57]

Assessed the position of impacted maxillary canines and graded them into different groups based on their location (Types A-J). Type B (47 %) was the most common, in which the canine is impacted vertically behind the apical one-third of the lateral incisor, causing root resorption, followed by types A and C, in which the canine is either impacted vertically between the lateral incisor and first premolar without causing root resorption or horizontally behind the apical one-third of the central incisor, causing root resorption (16 % and 17.1 %). Types J and I were the most uncommon types (0.4 % respectively)

4.8　Chapokas et al.[38]

The surgical approach to the impacted tooth's position was categorized into the following types (Table 2). Type I: Impacted maxillary canines are located palatally. A surgical procedure with gingivectomy is recommended for this type of impacted canines. A fixed attachment appliance should be applied as soon as the impacted tooth is exposed (Figure 12). The advantages of this method include the procedure's relative simplicity, the possibility of spontaneous eruption following surgical exposure, and the presence of a stable connection if a spontaneous eruption does not occur.[38] Ferguson and Parvizi,[61] found that 5.1 % of impacted canines exposed following gingivectomy required a second surgical treatment due to a lack of spontaneous eruption. Schmidt and Kokich[62] stated that most palatal impacted canines would spontaneously erupt after simple surgical removal of the overlaying palatal tissue. The use of orthodontic force immediately following surgical exposure of palatal impacted canines should be approached with precaution.[63] A lateral direction of eruption force may cause crown impaction against the alveolar process. This can cause nonphysiologic bone resorption, which can prolong orthodontic treatment.[63,64] The primary disadvantage of a gingivectomy is the possibility of a prolonged surgical recovery period.[62] Postoperative discomfort questionnaires and analgesic usage evaluation analyzed pain threshold variations between open and closed eruption approaches in managing impacted maxillary canines and discovered that the open technique had a longer recovery duration than the closed approach.[63] However, there was no variation in general daily activity. Type II: Impacted maxillary canines are found in the center of the alveolar crest or labial to the alveolar crest but

not overlaid labially to the adjacent lateral incisor's root. A closed eruption approach with a repositioned flap is suggested in this instance (Figure 13).[65] A full-thickness mucoperiosteal flap is reflected for the closed eruption procedure, enabling the operator to access the impacted tooth. Following follicular debridement, a fixed attachment, such as a wire or chain, is bonded to the impacted tooth. To its location, a crestal incision of 3 mm of keratinized gingiva labial should be performed. Following that, the flap is sutured back to its original location. The wire or chain may escape the flap, leaving the labial keratinized gingiva intact. Depending on the direction of force, this surgical method should achieve forced eruption through an appropriate zone of keratinized gingiva. If keratinized gingiva is missing, the patient should be advised that a revision with additional mucogingival surgery may be required to optimize esthetics. The key benefits of this method are less postoperative discomfort compared to gingivectomy and the control of forced eruption through a zone of keratinized gingiva. When compared to the open eruption approach, disadvantages include increased technique sensitivity due to adequate soft tissue flap management and a longer surgical treatment time.[60] Type III: Impacted maxillary canines are found labially to the root of the adjacent lateral incisor. A canine with its cusp tip over the root of the lateral incisor and the tooth bud palpable labially could be seen on an orthopantomogram radiographic assessment.[66] The lateral incisor is frequently palatally inclined to fit this location. For impacted canines in a type III position, an apically positioned flap (window flap) is acceptable.[66] A partial-thickness dissection of 2 to 3 mm of coronally connected gingiva is performed. The flap is positioned apically by making two parallel, vertical releasing incisions (Figure 14). The clinical crown of the impacted tooth will be entirely exposed with this method. The orthodontist will be able to see the impacted tooth as a result of this. Eruption force directions can then be chosen to minimize potential lateral incisor damage.[66] In addition, the width of the keratinized gingiva will grow during orthodontic forced eruption if this procedure is used.[67] Consequently, the key benefits of this method are increased visibility of tooth orientation and preservation of keratinized gingiva. The disadvantages of the window flap include its higher level of technique sensitivity when compared to the previously described gingivectomy and repositioned flap. Several investigators have also reported complications, including the possibility of a soft-tissue recession and insufficient access to the labial bone.[65] Orthodontic force should be used within a

few days of surgical exposure for types II and III canine impaction.[63]

Table 2: The surgical approach of impacted maxillary canines.		
Category	Location	Surgical technique
I	Palatal	Gingivectomy
II	Center of alveolar ridge or labial	Repositioned flap
III	Labial to the long axis of adjacent lateral incisor root	Apically positioned flap

Fig. 12: A gingivectomy is the appropriate surgical therapy for a canine with a palatal impacted tooth. At the time of surgical exposure, a gold button and chain were attached.[38]

Fig. 13: Apically to the mucogingival junction and labially in the alveolar process, the maxillary left canine is located. After suturing the flap, a chain was connected to the impacted tooth and escaped the flap through the crestal incision.[38]

Fig. 14: The maxillary right canine is labial to the long axis of the adjacent lateral incisor root. A window flap with an apical position was created.[38]

5. DISCUSSION

Permanent canines, according to most clinicians, are necessary for a functioning and stable occlusion and play an important role in establishing an attractive smile. Dentofacial features should be well established.[9] Consequently, the primary function of orthodontists is to align the impacted canines.[68] Treatment of impacted canines is a major challenge and lengthy orthodontic treatment mechanics that most of the time require an interdisciplinary treatment approach involving specialists from various disciplines such as orthodontists, oral surgeons, pediatric dentists, periodontists, and general dentists cooperating to successfully manage this condition and place the tooth in its correct position.[31,69] Although orthodontic movements can expose and correct superficially impacted canines, deeply impacted canines must be

disimpacted surgically.[70,71] Without surgical intervention, labial impacted canines may arise in the alveolar ridge or the sulcus.[12] Palatal impacted canines, on the other hand, rarely spontaneously erupt. Due to the palatal mucosa's resilience, surgical exposure would be required by removing the underlying mucosa and/or bone.[72] As a result, the need for orthodontic and surgical therapy becomes more challenging. Canine impaction can result in esthetic and phonetic compromises, loss of arch width and length, tooth migration, referred pain, cystic lesions, tumors, infections, and an increased prevalence of temporomandibular joint (TMJ) disorders.[20] Furthermore, impacted canines can impact dental health by causing root resorption in adjacent teeth; therefore, early detection is essential.[31,9] In other words, resorption of adjacent tooth roots may be a significant result of an irregular path of canine eruption within the dental alveolar process, compromising the longevity of these teeth.[12,73] A higher degree of canine displacement may be related to severe incisor root resorption.[73] Because this process is asymptomatic, when the resorption is clinically detected, it may have progressed to the point that conservative treatment is no longer an option.[5,9] Archer and Ericson and Kurol classification systems were used in classifying impacted canines, but not all types of canine impaction.[54,55] Furthermore, the drawbacks of using a 2D radiograph are magnification, superimposition, and distortion. The classification conducted by Lindauer et al.[56] aimed to enhance Ericson and Kurol's strategy. However, this study lacks information on the precise position, direction, and angulation of impacted canines, including angulation to the midline, vertical canine height, canine root apex position, and canine overlap with adjacent teeth due to superimposition, which is a major disadvantage for evaluating impacted canines. Furthermore, Clark's buccal object rule had tissue superimposition, a disadvantage when assessing impacted canines. Consequently, this is not the most efficient method of locating an impacted tooth and its surrounding structures. In addition, Kau et al.[18] employed the KPG index, which was not verified as a reliable approach for measuring treatment time and difficulty of surgical therapy of impacted canines. Ghoneima et al.'s[57] classification also has certain limitations. All different types of impacted canines were not represented. A surgical classification of impacted maxillary canines was discussed, with the width of keratinized gingiva and tooth placement influencing the recommended surgical approach. Following surgical exposure and orthodontic forced eruption of the impacted maxillary canines, several complications may occur, including root resorption, periodontal abnormalities, poor esthetic result, and immobility. When incisor roots are next to impacted maxillary canines, root resorption is quite common. Females have a higher prevalence than males.[74-79] It has revealed root resorption related to impacted canines in 27 % to 38 % of adjacent laterals and 9 % to 23 % of adjacent centrals.[80] Although there have been concerns about periodontal issues following the forceful eruption of impacted maxillary canines, there has been no substantial increase in periodontal pocket depth, recession, or width of keratinized gingiva.[81] To overcome the limitations of 2D radiographs, a clinician can use a CBCT image to assess the location of impacted canines and select the best therapy strategy to minimize surgical trauma to the surrounding hard and soft tissues.[52] It also reduces the biomechanics involved in canine retraction using fixed orthodontic appliances. The benefits of a CBCT image ensure an ideal radiography approach for detecting both the impaction and the surrounding structures.[48] The CBCT digital acquisition system can be used in various dental fields, including orthodontics, oral diagnostics, oral

surgery, endodontics, and implantology, among others.[51] However, to manage the principal use of CBCT in dental subjects and specialties, it is important to analyze tooth location, length, direction, related structures, and dental arch measurements.[82] The radiation risk when utilizing CT is extremely questionable. As a result, the main advantage of CBCT versus a CT scan is the lower radiation exposure.[16] The use of CBCT can surely aid in the accurate and quick diagnosis and the appropriate therapeutic intervention.[48,83] The esthetic outcome of 16 patients treated with the forced eruption of unilaterally impacted canines was assessed in a retrospective study. A panel of orthodontists was able to identify the previously impacted teeth in posttreatment images 78.9 %.[62] Alignment (17 %), torque/tooth inclination (28 %), crown length/wear (13 %), attached gingiva height relative to contralateral tooth (27 %), and recession are all factors for identification (6 %). Orthodontic final tooth movements and surgical soft tissue management necessitate meticulous attention in order to achieve the best esthetic outcomes. Immobility can be caused by one of three factors: (1) ankylosis, (2) incorrect orthodontic mechanics, or (3) bone remaining around the crown of the impaction.[63,9] There is a scarcity of literature on treatment prognosis for immobility. If a forced eruption of the impacted tooth fails, further prosthodontic options for tooth replacement, such as extraction followed by implant implantation, conventional fixed dental prosthesis, and removable prosthesis, may be considered. Dental implant placement may be complicated by the extraction of the impacted tooth. Consequently, remodeling the alveolar process may be required to optimize the esthetic result. Long-term survival rates for fixed prosthodontic options such as mesial cantilever and 3-unit fixed dental prostheses are acceptable.[83-87] However, these frequently require preparing a tooth that is healthy, noncarious, or restored. The long-term and short-term stability of resin-bonded permanent dental prostheses has been questioned.[88-91] One of the important clinical implications of applying the correct classification system for impacted canines is that it may include characteristics that aid proper assessment and treatment while also representing distinct forms of impacted canines. In 2019, Hsu et al.[92] reported that the key to treating the impacted canines successfully is their accurate localization. Understanding detailed information about displaced canine types is critical for improving treatment outcomes and facilitating examination and diagnosis.[26,51,52] Table 3 summarizes the list of studies that assessed the location of impacted canines. Proper knowledge of the condition and possible treatment options by the clinician may reduce treatment time, treatment complexity, and future complications and significantly impact treatment outcomes. Therefore, clinicians should be competent to conduct appropriate investigations, provide accurate diagnoses, develop the best treatment plan, and provide appropriate treatment for each patient, ensuring that each patient achieves the best possible outcome. The limitations of this study were that the search for the literature review was confined to the Scopus and PubMed databases. This may not include the entire published articles on impacted canines in the literature due to the time limitation, which resulted in the exclusion of some articles from the study articles list. Hence, the top articles which achieved the maximum citation were included in this study. Future studies can be planned to a broader category to include more articles. More research is needed to clarify the orthodontic prognosis of surgically exposed forced eruption.

Table 3: List of studies that assessed the location of impacted canines. Studies published until January 2021 were included.
Author	**Purpose of study**	**Methodology**	**Outcomes/limitations**
Clark[53]	Assess the location of impacted canines based on a periapical radiograph.	The buccal object rule was used to determine the bucco-palatal position of impacted canines in the parallax technique (Same Lingual Opposite Buccal (SLOB)) using two periapical radiographs at different angles of x-ray tube projection.	If the tooth moves in the same direction as the beam, it is palatal in the arch. If the tooth moves in the opposite direction, it is buccal in the arch.
Archer[54]	Assess the location of impacted maxillary canines based on the panoramic view.	Impacted maxillary canine position was divided into five categories: (I) Palatally placed, (II) Labially placed, (III) Partly on the labial side and partly on the palatal side, (IV) Canine locked between the roots of adjacent teeth, (V) Canine in the edentulous maxilla.	In comparison to other sectors, canines in sectors II and III had significantly successful eruptions. However, this study was conducted utilizing a 2D radiograph, which has the drawback of being inaccurate and overlapping anatomical components due to superimposition, distortion, and magnification.
Ericson and Kurol[55]	Identify types of impactions and assess prognostic factors for orthodontic and surgical treatment of maxillary canine impaction based on the panoramic view.	The following sectors were used to describe the impacted maxillary canine location: (1) If the cusp tip of the canine is between the long axis of the central incisor and the inter-median incisor's line, (2) If the cusp tip of the canine is between the lateral and central principal axes, (3) If the cuspid height of the canine is between the first premolar and the lateral central axis.	The smaller the alpha angle, the better the eruption results. Sector 1 has a longer orthodontic and surgical treatment duration than sector 3.
Lindauer et al.[56]	Study the impacted canines using a different strategy from Ericson and Kurol's.	The location of impacted canines was divided into four sectors: (I) The area distal to a line tangent to the distal heights of the contour of the lateral incisor, (II) The area mesial to the sector I but distal to a line bisecting the mesiodistal measurement of the long axis of the lateral incisor, (III) The area was mesial to the sector II but distal to a line tangent to the mesial heights of the contour of the lateral incisor, (IV) All areas mesial to the sector III.	78 % of the canines destined to get impacted had cusp tips in sectors II, III, and IV.
Kuftinec and Shapira[59]	Investigate the position of the maxillary canines based on a 2D panoramic view.	The cusp tip of the maxillary canines was selected to detect the bucco-palatal location of impacted canines.	If the canine cusp tip overlaps the root of the adjacent lateral incisor, the canine is impacted labially. In contrast, the palatal impaction is assumed when the cusp tip of the maxillary canines is medial to the long axis of the adjacent lateral incisor.
Sudhakar et al.[93]	Evaluate the bucco-palatal location of impacted canines.	The panoramic radiograph was selected to assess the bucco-palatal location of impacted canines in the central, coronal, and apical areas.	In the central and coronal locations, a panoramic radiograph could be used to assess the bucco-palatal position of impacted canines. In the apical area, other advanced imaging modalities, such as a 3D radiograph, are required.
Yavuz et al.[94]	Examine the location of mandibular canine impaction based on their angulation and depth using a panoramic radiograph.	The mandibular canine impaction was categorized as distoangular, mesioangular, horizontal, or vertical in terms of angulation. In terms of depth, level A refers to the crown of the impacted canine being at the cervical line of the adjacent teeth, and level B refers to the root apices of the adjacent teeth being between the cervical line and the crown of the impacted mandibular canines being beneath the root apices of the adjacent teeth. Level C refers to the crown of the impacted mandibular canines beneath the adjacent teeth' root apices.	Surgical intervention is indicated either by horizontal angulation of the canine impaction or the crowns of the impacted mandibular canines beneath the root apices of the adjacent teeth.

Kau et al.[18]	Assess the location of impacted maxillary canines using a 3D radiograph.	Assess the location of impacted maxillary canines based on the X, Y, and Z planes, and the cusp and root tips were given a score based on their deviations from the standard position. After that, the cumulative score is used to evaluate the difficulty of surgical and orthodontic treatment. Every impaction was categorized into easy (0-7), moderate (8-14), difficult (1-19), and extremely severe (20+) difficulty levels.	Four canines were graded as easy, eleven as moderate, nine as difficult, and four as extremely difficult. The average treatment times associated with months were simple: 11.23, moderate: 11.36, difficult: 12.76, and extremely difficult: 13.23.
Ghoneima et al.[57]	Assess the position of impacted maxillary canines.	The impacted maxillary canines were graded into different groups based on their location (Types A-J).	The most common type was type B (47 %), followed by types A and C (16 % and 17.1 %).

6. CONCLUSIONS

Sound knowledge of the canine morphology is essential for documenting and simplicity of interdisciplinary communication among clinicians. All the classification modalities noted to date have their advantages and shortcomings. While Archer classified in two directions and did not classify multidirectional positions or complex configurations, Ericson and Kurol's classification went further, with Lindauer adding supplemental types to the latter. Ghoneima et al.'s classification system categorized impacted canines into distinct categories based on their location, considering the canine configuration. However, there were certain drawbacks. Normal canine development, relevant investigations, and dental anomalies such as peg-shaped lateral incisors that occur concurrently should all be known to practitioners so that early detection and intervention can be carried out. Depending on the severity of the impaction, interceptive treatment alone may be sufficient. Surgical exposure of the impacted tooth and orthodontic alignment of the impacted tooth is frequently required. Early detection and appropriate referral for orthodontic treatment are critical in such instances. Further verification studies should compare other mechanics. More evidence is needed to determine the orthodontic prognosis of surgically exposed forced eruption. The different modalities used to diagnose canine impaction are reviewed in this article, along with an overview of current 3D modalities. The literature review supports the fact that the proper investigation of canine impaction via 3D images gave superior results in localizing the actual position of impacted canines compared to 2D imaging. This confirms that 3D images could be used to diagnose and localize the impacted canines instead of the conventional 2D method. Canines are critical for occlusal stability and esthetics, so offering clinicians a complete picture of their different types of impactions is essential for a successful treatment plan. This article provides guidelines for deciding on a surgical method depending on the location of impacted teeth and anatomical characteristics. The inclusion of this method in a clinical setting would save clinicians' time in pre-operative planning and patient management costs. The present study provided an impressive source of information on impacted canines. This will be a valuable resource for students, researchers, and clinicians in the dental field, with a particular focus on orthodontics.

7. AUTHORS' CONTRIBUTIONS

Dr. Yahya H. Y. Alfarra (Y.H.Y.A.) conducted the study as part of the PhD program, developed the concept and idea, managed the data collection process, carried out project administration activities, and wrote and submitted the manuscript. The article publication charge was fully paid by Dr. (Y.H.Y.A.). The authors reviewed the study report.

8. CONFLICTS OF INTEREST

There are no conflicts of interest.

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