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Original article

Impacted Canines: A Retrospective Study of the Prevalence, Causes, Diagnosis, and Management with Open and Closed Surgical Approach

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Abstract
Impaction is a tooth that fails to erupt into its normal functioning position in the dental arch within the expected time and will not attain its anatomical position beyond the chronological eruption data, even after its root completion. When maxillary impacted canines (MxIC) and mandibular impacted canines (MnIC) are impacted, they can present significant functional and esthetic dilemmas to the patient and clinician. This study was designed to evaluate the prevalence, causes, diagnosis, and management of maxillary canines using two different surgical approaches: open and closed surgical exposure. The sample consists of 310 patients, 264 females and 46 males, among them 11 cases were subject to a comparative study to evaluate the difference between the closed and open surgical approach on different clinical parameters. This paper described the development, incidence, etiology, and diagnosis of the impacted canine. This article discussed the techniques that can be used in guiding the direction or altering the direction of impacted canines to bring them into occlusion. It highlights the steps required for proper clinical and radiographic examinations and surgical intervention selection based on the literature available. A cross-sectional retrospective study of all patients who attended Almadane dental clinic in Caser Ben Gashier and the Libyan Academic Dental Center in Tripoli, Libya. Inclusion criteria were individuals aged 15 years and older and no history of orthodontic treatment. The data were collected from the routine medico-legal orthodontic records. All OPGs were taken using standardized equipment. Data were explored for frequency and pattern of canine impaction in regards to gender difference, anatomical position difference. A total of 310 individuals fulfilled the inclusion criteria with a mean age of 18 ± 13.5 years. Of the total sample, 25 individuals had at least one maxillary and /or mandibular canine impaction, Canine impaction occurs more in females than males, 5:1%. In this sample, the frequency of MxIC was 8% and MnIC was 2.9%. The (MxIC) occurred in 8% of the sample, bilateral (MxIC) occurred in 4%, and Unilateral (MxIC) occurred in 3.9%. Unilateral canine impaction on the right side was 0.9%, and 2.5% Unilateral (MxIC) left side. The location of the (MxIC) was 4.8 % palatally and 3.5% buccally. while mandibular canine impaction occurred in 2.9 % of the cases, bilateral (MnIC) was 0.9%, unilateral (MnIC) on right side was 0.6%, and 0.9% was unilateral (MnIC) on the left side. (MnIC) buccally located was 1.9%, and 0.9% was located lingually. Eleven cases were subject to a comparative study to evaluate the difference between the closed and open surgical approach on different clinical parameters, and the result showed no clinically significant difference between the open and closed surgical approach. The maxillary canines have the longest period of development, as well as the longest and most tortuous course to travel from the point of formation, lateral to the piriform fossa, until they reach their final destination in full occlusion, when canines are impacted, they can present significant functional and esthetic dilemmas to the patient and clinician. Therefore, proper management of impacted teeth is important to achieve long-term success, functionally and esthetically.
Keywords. Canine Impaction, Prevalence Impacted Canines, Maxilla, Bilateral, Unilateral.

Introduction

Impaction of maxillary and mandibular canines is a frequently encountered clinical problem. Maxillary canines are the most commonly impacted teeth, second only to the third molars. The order of frequency of impacted teeth is as follows: 1. mandibular 3rd molar, 2. maxillary 3rd molar, 3. maxillary cuspids, 4. mandibular cuspids, 5. Mandibular premolar 6. maxillary premolars 7. Maxillary central and lateral incisors.

It has been well reported in the literature that proper development of the canine teeth plays a major role in esthetics as well as in establishing proper dental arch form. Their position in the arch can be diagnosed by periapical radiographs, orthopantomogram, or CBCTs. Their path of eruption can be guided or redirected by using various techniques and bringing them into their arch. Understanding the development, incidence, and etiology of the impacted canine is important to reach a proper diagnosis and facilitate treatment planning to select the appropriate surgical intervention. Etiology and prevalence, maxillary canines have the longest period of development, as well as the longest and most tortuous course to travel from the point of formation, lateral to the piriform fossa, until they reach their final destination in full occlusion. During their course of development, the crowns of the permanent canines are intimately related to the roots of the lateral incisors. Broadbent cautioned against early correction of the flared and distally tipped lateral incisors for

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fear of either impacting the canines or resorbing the roots of the lateral incisors. Canines are important teeth in the development of the maxillary and mandibular dentition [1].

The canine tooth germ begins development at 4-5 months and is located very high in the anterior wall of the maxillary sinus, under the floor of the orbit. It is positioned above the root of the lateral incisor until the crown is calcified [2]. Eruption occurs around 11 years of age, and it takes approximately 2-3 years for completion of root development. Thus, the root is completely formed at approximately 13.5 years [3]. The maxillary canine generally travels on a mesial path until it reaches the distal aspect of the lateral incisor root. At this location, its uprights are oriented vertical position and eruption is guided by the root of the lateral incisor. The latter has been referred to as the "Guidance Theory," which proposes that the distal aspect of the lateral incisor root guides the canine into normal position [4]. Maxillary canine impactions occur in approximately 2 % of the population [5], and it has a preponderance for females. The incidence of canine impaction in the maxilla is more than twice that in the mandible. The impacted maxillary canine has 8% chances of being impacted bilaterally.

The occurrence of palatal impaction is more common than labial impaction. Unlike buccal displacement of maxillary canines, the incidence reported varies between 0.8% to 2.8% for the maxillary canines and 0.2% for the mandibular canines [6]. Unilateral impaction is five times more common than bilateral cases, and the left side is slightly more affected than the right [7]. Females are 2.8 times more likely to have impacted canines than males Dachi et al. [8] in 1961 found the incidence to be 1.2 % in females and 0.51% in males. With regard to the position of canine impaction within the arch, the maxillary canine is found in a palatal impaction 82% of the time, versus being in a buccal impaction position (18 %) [9]. Therefore, clinical examination by age 9-10 years, early detection, review of family history, as well as a radiographic assessment, is essential in the early detection of canine impactions. The most commonly impacted teeth are third molars, followed by canines [10]. Impacted canines generally present a challenge to the clinician attempting to align the dentition naturally. Surgical intervention is often required to expose the impacted canine. a procedure that must be planned carefully to optimize aesthetic and functional outcomes. Complications may include asymmetrical clinical crown length, uneven gingival height, or contour [11] should be avoided. Understanding the development, incidence, and etiology of the impacted canine is important to reach a proper diagnosis and facilitate treatment planning to select the appropriate surgical intervention.

This retrospective study was designed to evaluate the prevalence, causes, diagnosis, and management of maxillary canines with two different surgical approaches (open and closed surgical exposure for the impacted canines).

Methods

A cross-sectional retrospective study of all patients who attended Almadane dental clinic in Caser Ben Gashier and the LIBYAN Academic Dental Center in Tripoli, the Capital town of Libya. Inclusion criteria were individuals aged 15 years and older and no history of orthodontic treatment. The data were collected from the routine medico-legal orthodontic records. All OPGs were taken using standardized equipment. The data were collected from the patient's medico-legal records. All the patients underwent intraoral examination, palpation, followed by panoramic, occlusal, and periapical radiographs if required to localize the position of the impacted canine. Lateral shift periapical radiograph technique, occlusal film as well as dental CBCT scans were advised. History of trauma to the maxilla or mandible and local pathological conditions such as developmental cysts, as well as patients with hereditary diseases such as Cephalocraniodysostosis and Down's syndrome, were excluded from the study.

A tooth was considered to be impacted when it fails to erupt into its normal functioning position in the dental arch within the expected time and will not attains it's anatomical position beyond the chronological eruption data even after it's root completion, or it was obstructed by the adjacent teeth, bone, or soft tissue [11]. Eleven 11 cases was subject for a comparative study to evaluate the difference between the closed and open surgical approach on different clinical parameters as duration of surgical exposure procedure, Patient discomfort and pain after surgery, time needed for canine eruption from surgical exposure of the canine until it was well positioned, Orthodontic treatment complications and difficulties, periodontal outcomes such as gingival recession, bone support, width of keratinized gingiva, and mean pocket, aesthetic out comes as crown length, shape, and inclination. A written informed consent was obtained from all the patients.

Causes of canine impaction

Except for the third molars, maxillary canines are among the last teeth to erupt. They usually develop high in the maxilla and need to travel a considerable distance before they erupt. Canine impaction can be due to hereditary reasons. They can be impacted due to localized, systemic, or genetic reasons. Localized factors include arch length tooth size discrepancies, failure in the resorption of primary canine, prolonged retention or early loss of primary canine, ankylosis of permanent canine, cysts or neoplasm, dilacerations of root, absence of maxillary lateral incisor, and trauma to the deciduous tooth bud, disruption of the normal eruption sequence, lack of space, rotation of tooth buds, premature root closure, canine eruption into a

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cleft, supernumerary teeth, heavy fibrous gingiva, variation in the timing of lateral incisor root formation, iatrogenic factors, and idiopathic factors. Systemic factors include endocrine disorders, radiation, febrile diseases, and vitamin D deficiency.

Sequelae of impaction

The squeal of canine impaction can be summarized as following: a) impaction labial or lingual mal positioning of the impacted tooth, (b) migration of the neighboring teeth and loss of arch length, (c) internal resorption, (d) dentigerous cyst formation, (e) external root resorption of the impacted tooth, as well as the neighboring teeth, (f) infection particularly with partial eruption, (g) referred pain.

Clinical evaluation and diagnosis

Clinically, palpation of the canine prominence is important to aid in determining the presence of the permanent canine. When the primary canine is retained past its normal age of exfoliation, accompanied by the absence of a canine bulge, this may be an indication of atypical canine eruption. In addition, the clinician should further investigate asymmetry in the canine bulge, aberrant eruption sequence, and distal tipping or migration of the lateral incisors as alternative indicators for canine impaction [10-11]. Clinical and radiographic assessments are essential tools in evaluating the presence and location of the impacted canine. The clinician must consider the amount of space in the dental arch, morphology and position of adjacent teeth, contours of the bone, mobility of the teeth, as well as a radiographic assessment to determine the position of the impacted canine in three dimensions [4]. The prognosis depends on the age of the patient, availability of space, favorable position of the canine, and presence of adequate width of attached gingiva. The position of a canine can be determined by its relation to the midline. The vertical position is determined about the lateral incisor's root, as said by Peck and Peck.

Radiographic evaluation

Although various radiographic exposures, including periapical films, occlusal films, panoramic views, and lateral cephalograms, can help in evaluating the position of the canines, in some cases, periapical films are reliable for that purpose. CBCT With reduced radiation doses compared with those of medical CT, whilst offering three-dimensional (3D) imaging capability for displaying the head and neck. The rapid development of CBCT scanning combined with 3D rendering techniques produces high-resolution images that have been proven to be useful for the diagnosis of impacted canines, treatment planning, and the identification of associated complications, such as root resorption in adjacent incisors. CBCT overcomes the limitations of conventional two-dimensional (2D) imaging.

A **B** **B**

Figure 1. (A) Occlusal film showing the palatally impacted canine, (B) Orthopanoramic (O P G) radiographs showing impacted canines.

Figure 2. CBCT showing buccally impacted canine. CBCT overcomes the limitations of conventional two-dimensional (2D) imaging.

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Management
The impacted maxillary canine may be managed by several different techniques. The chosen method would depend on the degree of impaction, age of the patient, stage of root formation, presence of any associated pathology, dental condition of the adjacent teeth, position of the tooth, patient's willingness to undergo orthodontic treatment, available facilities for specialized treatment, and patient's general physical condition. It can be done as an interceptive treatment, with varying strategies for labial impaction, palatal impaction, and variation in the surgical intervention techniques, as well as the way of canine traction, is of great importance to be given in planning the retention phase. Canine impaction management can be summarized as follows:

No treatment (leave the tooth in situ).
In some asymptomatic cases, no treatment may be required apart from regular clinical and radiographic follow-up. There is a small risk of follicular cystic degeneration, although the incidence of this is unknown. Rarely, odontogenic tumors may develop around the impacted tooth.

Interceptive treatment.
This can be attempted when early detection of signs of ectopic eruption and a selective extraction of the deciduous canine as early as 7 to 8 years (Suggested by Williams). Ericson and Kurol [12] suggested that removal of the deciduous canines before the age of 11 years will normalize the position of the ectopically erupting permanent canines in 91% of the cases if the canine crown is distal to the midline of the lateral incisor.

Surgical exposure of the tooth.
This technique may be used in cases where there is enough space for the canine to erupt and where the root formation is incomplete. Surgically exposing the crown of the canine may allow it to come into position by normal eruptive forces.

Surgical removal of the impacted tooth.
This technique is preferred for teeth that are in an unfavorable position and are likely to cause problems in the future. It may also be considered when a patient is not willing to undergo orthodontic treatment or cannot afford it, even if the impacted tooth is in a favorable position.

Tunnel approach.
The impacted canine is drawn downwards through the evacuated socket of the simultaneously extracted deciduous canine. This modification is aimed at ensuring the preservation of the buccal plate of the alveolar bone, and the principal indication of this technique is for impacted canines that are located high in the maxilla and near the line of the arch [13].

Surgical repositioning/auto transplantation
Impacted canines that are malpositioned, but have a favorable root pattern (without hooks or sharp curves) may be considered for autotransplantation into the dental arch. This may be done by utilizing the socket of the deciduous canine or first premolar, depending on the amount of space needed and available [14].

Surgical exposure and orthodontically assisted eruption
It is indicated when the tooth doesn't erupt spontaneously after creating space in the arch, and it is attempted after root formation. The flap should be designed to preserve a band of attached gingival tissue to guide the eruption of the tooth through its natural path of eruption. For attempting this technique, the case must fulfil the following criteria: (a) The impacted canine must be favorably positioned. (b) The patient must be compliant with both surgery and long-term orthodontic treatment. (c) The patient must not have associated medical problems.

Open technique
This can be done as an excisional approach when the canine is coronal to the mucogingival junction, and an apically positioned flap is done when the canine is apical to the mucogingival junction. an open window technique is done where a flap is raised, the bone covering the crown is removed and a small window or fenestration is made and the orthodontic attachment is bonded, and the flap is sutured back into place. This technique involves surgically uncovering the canine tooth, as before, but instead of bonding an attachment on the exposed tooth at the time of the surgery, a window of tissue is removed from around the tooth, leaving it exposed. A dressing or 'pack' is placed to cover the exposed area. The dressing is removed approximately 14 days later. The tooth is then either left to erupt naturally, or an orthodontic attachment is placed to enable the tooth to be moved, above the gum, into its correct position in line with the rest of the teeth [15].

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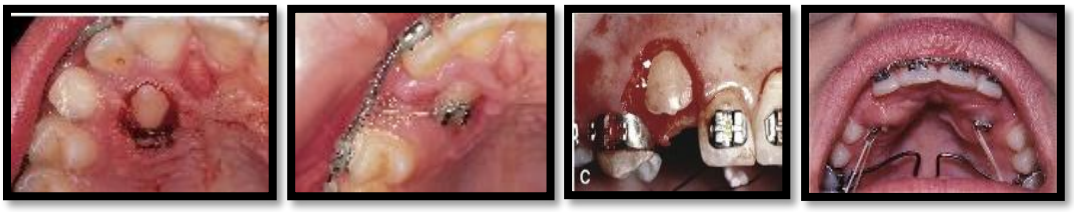

Figure 4. Open surgical approach technique.

Closed technique

This technique is performed when the tooth is impacted in the centre of the alveolus. The flap is elevated, and the attachment is placed on the impacted tooth (can be a master bracket, button), and they are attached to the main arch wire through a ligature or chain placed over the attachment after a week. The raised flap is then repositioned to its original position. Soon after surgery, the canine is gently brought into its correct position using an orthodontic appliance. Thus, the canine moves into position beneath the mucosa. For the most predictable outcomes with the closed eruption technique, the impacted tooth should first be erupted lingually and then moved laterally so as not to compromise the bone levels or cause root resorption of the lateral incisor.

Figure5. Closed surgical approach technique

To expose a palatally impacted canine to the oral environment, there are mainly two exposure techniques: An 'Open' exposure, which involves raising a palatal flap, removal of bone and mucosa overlying the tooth, and placement of a surgical pack. The cuspids is subsequently orthodontically aligned above the mucosa, on the other hand, closed exposure involves raising a palatal flap, limited removal of bone and instead of excision of the overlying palatal mucosa, an attachment is bonded to the crown of the exposed cuspids, allowing alignment of the tooth from below the mucosa Parkin et al., [15-16]. There are several advantages and disadvantages of each technique (open and closed), and a debate about which one is preferred over the other. According to Parkin et al., [17], a study on open versus closed surgical exposure of canine teeth that are displaced in the roof of the mouth, a systematic review, suggests that there is no difference in outcomes when performing an open or closed technique for unerupted palatally displaced maxillary canines.

Results

Data were explored for frequency and pattern of canine impaction in regards to gender difference, anatomical position difference. A total of 310 individuals fulfilled the inclusion criteria with a mean age of 18 ± 13.5 years. Of the total sample, 25 individuals had at least one maxillary and /or mandibular canine impaction, Canine impaction occurs more in females than males, 5:1%. The maxillary canine impaction occurred in 8% of the sample, bilateral maxillary canine impaction occurred in 4%, and unilateral max. canine impaction occurred in 3.9%. unilateral canine impaction on the right side was 0.9%, and 2.5% unilateral max. Canine impaction left side. The location of the maxi. impacted was 4.8 % palatally and 3.5% buccally. while mandibular canine impaction occurred in 2.9 % of the cases, bilateral mandibular canine impaction was 0.9%, unilateral impaction right side was 0.6%, and 0.9% was unilateral mandibular canine impaction on the left side. Mandibular canine impaction buccally located was 1.9%, and 0.9% was located lingually. Eleven 11 cases were subject to a comparative study to evaluate the difference between the closed and open surgical approach on different clinical parameters, and the result showed no clinically significant difference between the open and closed surgical approach.

Table 1. Sample distribution by gender

Sex of the patient	Patient	Percentage %
Females	246	85%
Males	46	14.8%

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Table 2 shows that canine impaction occurs more in females than males, 5:1%. In this sample.

Table 2. The distribution of impacted canines according to gender

Gender	Sample no	No. of impaction	%of impact on sample
Female	246	21	6%
Male	46	4	1.2%

Table 3 shows that maxillary canine impaction occurred in 8% of the sample, bilateral maxillary canine impaction occurred in 4%, and unilateral max. canine impaction occurred in 3.9%. unilateral canine impaction on the right side was 0.9%, and 2.5% unilateral max. Canine impaction left side. The location of the maxi. impacted was 4.8 % palatally and 3.5% buccally.

Table 3. The distribution of maxillary impacted canines MxIC according to the site of the impaction

Gender	Sample no	No. of impaction	% of impact on sample	Maxillary impaction	MxIC			MxIC location	
					Bilateral MxIC	Unilateral MxIC		Buccally	palatally
						RT	LT		
Total	310	25	8%	25	13	3	8	11	15
Female	246	21	6%	21	11	2	7	10	12
Male	46	4	1.2%	4	2	1	1	1	3
%	%	8%		8%	4%	0.9%	2.5%	3.5%	4.8%

Table 4 shows that mandibular canine impaction occurred in 2.9 % of the cases, bilateral mandibular canine impaction was 0.9%, unilateral impaction right side was 0.6%, and 0.9% was unilateral mandibular canine impaction on the left side. Mandibular canine impaction buccally located was 1.9%, and 0.9% was located lingually.

Table 4. The distribution of mandibular impacted canines MnIC according to the site of the impaction

Gender	Sample no	Distribution of MnIC	Mandibular canine impaction MnIC				
			Bilateral MnIC	Unilateral MnIC		Location of MnIC	
				RT.	LT.	Buccally	Lingually
Total	310	9	3	2	3	6	3
Female	246	7	2	1	3	5	2
Male	46	2	1	1	0	1	1
%	%	2.9%	0.9%	0.6%	0.9%	1.9%	0.9%

Table 5 shows the difference between the closed and open surgical approach on different clinical parameters, and the result showed no clinically significant difference between the open and closed surgical approach, with only exception on orthodontic treatment complications and difficulties, where the open technique show fewer and easier orthodontic reattachment.

Table 5. The closed versus open surgical exposure technique: the clinical difference.

Clinical evaluation parameters	Open technique	Closed technique
Duration of the surgical exposure procedure	N S D	N S D
Patient discomfort and pain after surgery	NSD	N S D
Time of canine eruption: time needed for the canine eruption from surgical exposure of the canine until it was well-positioned	Less time	More time
Orthodontic treatment complications and difficulties	Lesser, easier reattachment	More difficulties rate, need for surgical reopening if orthodontic attachment failed
Periodontal outcomes: gingival recession, bone support, width of keratinized gingiva, mean pocket depth	N S D	N S D
Aesthetic outcomes, crown length, shape, inclination	N S D	N S D

(N S D = Non-Significant Difference)

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Discussion

Numerous studies have been conducted on the incidence and prevalence of these teeth. Sample size, grouping methods, clinical examination, and radiographic confirmations have been different in various studies, making it difficult to compare the results of the present study with them. Distribution among the genders has been studied in various studies, and most of them have reported that the female-to-male ratio is more; 3:1 in most of the studies [5]. Our study results agreed with a previous study that canine impaction occurs in females more than males. This study showed a higher result, and the ratio calculated was 5:1, which was because of the sample distribution between males and females in this study (246 females and 46 males). There have been lots of hypotheses regarding the occurrence of supernumeraries and impacted teeth more commonly in females than males. One of them states that the smaller cranium in females is the cause, while other emphasizes that females are more concerned about their esthetics as compared to males, and that is why they seek orthodontic treatment more frequently and thus are diagnosed on routine examinations and radiographs with these conditions [21]. Canine impaction occurs in the maxilla more than the mandible (8%-2.9%). The dissimilarity between the prevalence of these teeth in the maxilla and mandible is attributed to the fact that maxillary canines are the last teeth to develop, and they have to travel a long path before coming into occlusion. During this path of eruption, the chances of mechanical obstruction and displacement are high [22], in the maxilla canine impaction occurs unilaterally more or less the same as bilateral MxIC unlike the previous studies, unilateral maxillary canine impaction occurs in the left side more than the right side, the location of the MxIC occurs palatally more than buccally [7]. The clinical comparison between the closed and open surgical approach agreed with the previous study and shows no significant difference in duration of the surgical exposure procedure [18], patient discomfort, and pain after surgery[19]. Periodontal outcomes: gingival recession, bone support, width of keratinized gingiva, mean pocket depth [20], and aesthetic outcomes, crown length, shape, inclination [21]. On the other hand, the time of canine eruption, time needed for canine eruption from surgical exposure of the canine Until it was well positioned [20] in the open technique was less than that needed in the closed technique, and orthodontic treatment complication and difficulties [21] was less and easy reattachment in the open technique and more difficult and sometimes requires surgical reopening if the orthodontic attachment failed.

Conclusion

When maxillary impacted canines (MxIC) and mandibular impacted canines (MnIC) are impacted, they can present significant functional and esthetic dilemmas to the patient and clinician. General dental practitioners and orthodontists will commonly encounter this problem and need to be fully aware of managing this situation. Failure to diagnose and manage the ectopic upper canine efficiently can result in more complex remedial treatment becoming necessary. Simple interceptive procedures can be used to prevent impaction of the permanent canines by the extraction of the deciduous canines. Various surgical and orthodontic techniques are used to recover impacted maxillary canines. Management of impacted canines is necessary for maintenance of esthetics and function, so a proper knowledge about the canine impaction is important to achieve a proper management technique and a well-designed treatment plan, and adequate force must be applied for efficient eruption without damaging the adjacent teeth.

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