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Orthodontic Evaluation of Impacted Maxillary Canine by Panoramic Radiograph–A Literature Review

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ABSTRACT

The management of impacted maxillary canines (IMC) needs to formulate proper treatment plans that meet the patient's needs in terms of esthetics and function. This proper treatment plan depends on the clinical diagnosis, radiographic evaluation, and suitable interceptive treatment. The aim of this review is to incorporate the studies that include diagnosis, prognosis, and rules to predict MCI.

Key words Impacted Maxillary Canine, Panoramic Radiograph, Sector, Orthodontic Treatment

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INTRODUCTION

Impaction is defined as a pathological condition resulting from the lack of eruption of a tooth into the oral cavity within the limited time and physiology of the normal eruption process [1]. Canine is playing an essential role in the support of facial appearance, dental aesthetic, functional occlusion, and arch development [2,3]. The maxillary canine is susceptible to be impacted in the second degree of impacted teeth after the lower third molar because it has the longest period of development and the most tortuous route to full occlusion [4]. The evaluation of the impacted maxillary canine (IMC) is very essential for orthodontic treatment to avoid unwanted side results and additional cost-effectiveness [5]. Panoramic radiography (PR) is a two-dimensional imaging technique that represents a broad anatomical area in a simple, fast, inexpensive, and with minimal hazard technique that could be used to evaluate the impacted teeth [6,7]. Various evaluation modalities including sector, angular, and linear measurements, and image magnification have been suggested by authors to predict unerupted maxillary canine. The aim of this review is to incorporate the studies that include diagnosis, prognosis, and rules to predict MCI.

Incidence

The IMC is considered the second incident tooth to be impacted, after the mandibular third molar which is come in the first percentage [8]. This incidence varies according to the ethnicity of the population [9], its range from 0.8% to 3.3% in the general population [10]. In the North Greek population, this incidence reaches 8.4% [11] and (9.7%) in the North Indian population [12]. The authors reported that the prevalence of IMC in Saudi Arabia ranges from 1.4 to 5.35% [13,14]. The Iraqi population shows 2.7 to 4.6% in canine impaction [15,16]. While in Kosovar population was 1.62% [17], in the Turkish population (1.74%) [18], and in the Cypriote population (3.53%) [19].

Unilateral MCI is more common than bilateral cases in about five times more, and the left side is affected more than the right side [20]. Only 8% of the impacted canines are bilateral [21]. Females have an impacted canine 2.5 times more than males [15,22], Hamozi et al. [10] show that females are more affected by impaction than males by 3.6 times. According to its position in the dental arch, the palatally positioned impacted canine is more commonly in 85%, than the labially impacted with 15% [8,23]. Altaee et al. [15] reported 61% of palatally impacted and 39% of labially located.

Etiology

The causes of IMC considered multifactorial pathos is, these include the long root of the tooth and a long path of eruption because the tooth develops deep into the jaw, thus it erupts following adjacent teeth [24]. Other possible local factors of impacted canines may include; inadequate space for eruption or arch length discrepancy leading to a tooth erupting buccally when crowding is present resulting in a labial rather than palatal impaction or an early loss of primary canines, abnormal position of the tooth bud, and trauma to the maxillary anterior region at an early stage of development [3].

There are two theories that have been suggested to explain the palatal impaction of canine; the guidance theory and the genetic theory. The guidance theory expected that the distal aspect of the lateral incisor is the

guide for canine eruption. Thus, the spaced dentition, abnormally small peg-shaped lateral or congenitally missing lateral incisor may result in palatal impaction of canine [25]. This theory supports that palatally displaced canines are frequently found even if these anomalies are genetically determined, the guidance theory states that the palatal canine displacement has not a similar genetic association but occurs as a result of these local environmental disturbances [26]. Stellzig et al. [27], reported that the congenitally missing lateral incisors can play an important role in about 35% of the time of canine impaction incidence. Majeed et al. [28] show in their study an only 13.3% of missing and 3.3% of peg-shaped lateral incisors have a relation with palatally impacted canines. However, this guiding theory is underreported by the fact that many cases of impacted canines have completely normal lateral incisors in form, volume, and position [29].

The genetic theory is suggested that palatal impaction of canine is associated with a developmental disturbance of the dental lamina. This theory indicates the multiple genetic origins of palatally impacted canines, such as familial and bilateral occurrence, sex differences, in addition to an increased occurrence of other significant common dental association's such as the ectopic eruption of first molars, infra-occlusion of primary molars, and aplasia of premolars [26], supernumerary teeth, odontomas, cystic lesions, delayed exfoliation of primary canine, early trauma to the maxilla, cleft lip and palate, ankylosis, crypt displacement, and syndromes such as Cleidocranial dysplasia [3].

The complication may result from untreated partially erupted or impacted canines such as shortening of the dental arch, formation of follicular cysts, canine tooth ankylosis, recurrent infections, pain, internal resorption, external resorption of the canine and adjacent teeth, or combinations of these factors [30].

Classification of impacted maxillary canine

The type and position of the IMC are necessary for proper diagnosis, route of treatment, and prognosis. According to the literature, the most common dependent classification of the impacted maxillary canine described by Yamamoto et al. [31] divided impacted maxillary canine into seven types according to angles between canine tooth long-axis and the occlusal plane (Figure 1). These types include:

Type I: Canine embedded between the lateral incisor and first premolar.

Type II: The crown is mesially tipped and overlapping and pressing the lateral incisor tooth to provide distal tipping of the lateral.

Type III: The crown is distally tipped and overlapping the root of the first premolar.

Type IV/V: Canine long axis is orientated horizontally.

Type VI: The canine crown is directed up toward orbital fossae.

Type VII: Canine long axis in a horizontal direction with its crown placed buccally or interchanging with adjacent teeth.

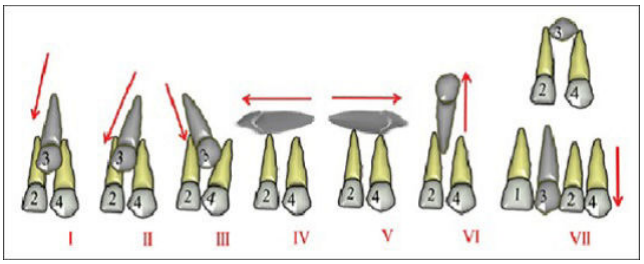

Figure 1: Classification of the maxillary displaced canines by Yamamoto et al. [31] Hamozi et al. [10].

This classification is essential in determining the degree of impaction and expressing a successful treatment plan. It uses the panoramic radiograph to apply the classification on right, or left side, in easy and simple analysis. A two-dimensional representation of a three-dimensional object considered as a shortcoming of this classification, where the tooth rotation, labio-lingual relationship, and exact root position cannot be determined [32].

Another classification of the impacted maxillary canine described by Ghoneima et al. [33] which classifies the impacted maxillary canine into ten groups (Types A to J) according to their positions and locations (Figure 2).

Type A: Canine is in a mesioangular position behind the central incisor root causing resorption in the apical one-third of its root.

Type B: Canine is in a vertical position behind the lateral incisor causing resorption of the apical one-third of its root.

Types C and D: Canine is in a vertical position either between the lateral incisor and 1st premolar or between the 1st and 2nd premolars.

Type E: Canines were in the mesioangular direction lying between the anterior-inferior wall of the maxillary sinus and the basilar part of the nasal cavity.

Types F and H: Canine is in a horizontal position either near to the inferior wall of the maxillary sinus with the crown positioned distally or between the lateral incisor and 1st premolar.

Type G: Canines were impacted vertically with their roots inside the maxillary sinus.

Type I: Canine is impacted completely inside the maxillary sinus.

Type J: Canine is palatally positioned.

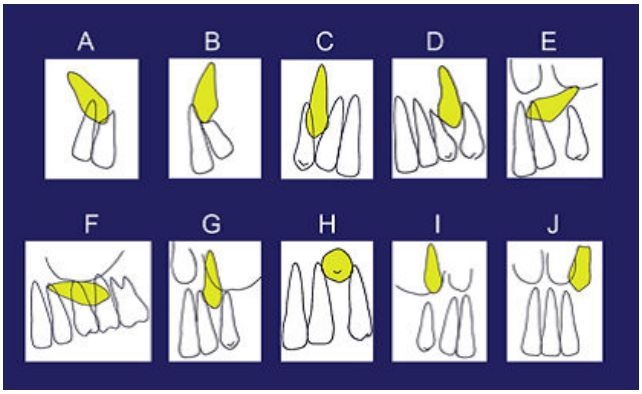

Figure 2: Classification of the displaced maxillary canines [33].

It's important for the impacted tooth to be diagnosed clinically and radiographically for orthodontic treatment planning. The clinical inspection and palpation of the canine prominence are important to assist in determining the presence of the permanent canine. When the deciduous canine is retained preceding its normal age of exfoliation, and accompanied by the absence of a canine bulge, this might be a sign of an atypical canine eruption. Moreover, the clinician should further investigate asymmetry in the canine bulge, aberrant eruption sequence, the amount of space for eruption, distal tipping or migration of the lateral incisors, and the mobility of teeth as alternative indicators for canine impaction [2,25].

Clinical signs of canine impaction are listed as a following [23]

- Delayed eruption of the permanent canine or prolonged retention of the deciduous canine.
- Absence of a normal labial canine bulge.
- Presence of a palatal bulge.
- Delayed eruption, distal tipping, or migration of the lateral incisor.

Radiographic evaluation

Radiographic evaluation of impacted canines includes the use of two-dimensional periapical, occlusal, panoramic, or frontal/lateral cephalometric radiographs, and recently the use of three-dimensional radiographic imaging such as cone-beam computed tomography (CBCT) has been reported [34]. An intraoral periapical radiograph can be used to localize the impacted canine by two radiographs taken in a different either horizontal or vertical angulation according to tube-shifting technique or Clark's rule. Occlusal films are used as a supplemental aid to determine the buccolingual position of the impacted canine [25,35].

Panoramic radiograph is simple, readily available, and provides initial overall comprehensive information of both dental arches and their supporting structures with a minimal dose of radiation. It is considered as a most important imaging tool that provides a satisfactory two-dimensional view of the impacted canine and it is location, angulation, and orientation relative to the erupted teeth. This information can be used to design the treatment and assess the approach and direction of orthodontic force application [3,14,36]. Frontal/lateral cephalograms can be used to determine the position of the impacted canine in relation to adjacent structures such as the maxillary sinus and the floor of the nose [25]. CBCT can identify and locate the position of impacted canines precisely. It can be used to assess any damage to the roots of adjacent teeth and the amount of bone surrounding each tooth [34]. However, increased cost, time, radiation exposure, make routine use of CBCT is limited [2].

Sequelae of canine impaction [20,30]

- Labial or lingual mal-positioning tooth.
- Migration of the neighboring teeth and shortening of the dental arch.
- Internal resorption.
- Dentigerous cyst formation.
- External root resorption of the impacted tooth, as well as the neighboring teeth.
- Canine tooth ankylosis.
- Infection particularly with partial erupt.
- Referred pain and combinations of the above sequelae.

Sector, angular and linear measurements systems

Various sector and angular classification systems and their modifications are available to assess the position and severity of maxillary canine impaction. Sector classification serves to locate the impacted maxillary canine in the mesiodistal direction, and vertical height in panoramic radiography by drawing lines. Different systems of sectors are mentioned in the literature.

Sector localization of IMC using PR is a simple and inexpensive method to aid in locating IMC [37], the PR is commonly prescribed by orthodontists as an overviewing image. With sector classification, the orthodontist can expect the location of the impacted canine by using single exposure with minimum radiation dose to the patients [36-38. The first sector classification introduced by Ericson [39] consisted of 5 sectors in PR to determine the horizontal crown position of impacted canine, in addition to the angulation of canine with the mid-sagittal plane (A), and the distance between the canine cusp tip to the occlusal plane to predict the position of the impacted maxillary canine (Figure 3).

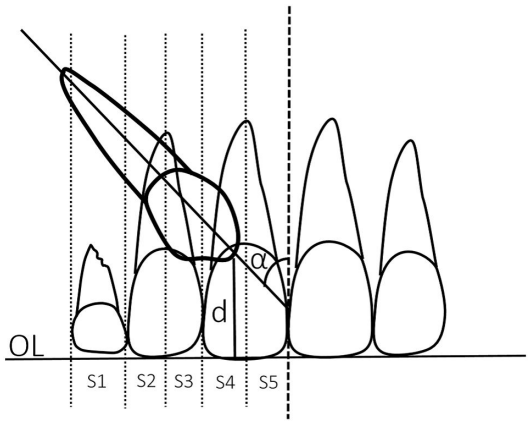

Figure 3: The 5 sectors to determine the medial crown position of the permanent maxillary canine in the panoramic radiograph described by Ericsonet al. [39]. Mesial inclination (a) To the midline and distance (d) To the occlusal line (OL).

The Ericson et al. [39] classification is modified by Lindauer et al. [40], to introduce a classification from 4 sectors (Figure 4). Then, Kim et al. [41] re-modified the classification predicted by Lindauer et al. [40] to introduce a new sector classification that with only 3 sectors [38].

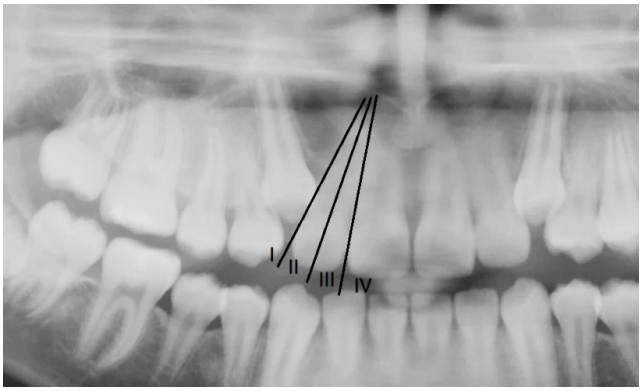

Figure 4: Digital panoramic radiograph shows sector classification described by Lindauer et al. [40].

Power [42] and Alqerban et al. [43] made another modification by adding an additional sector to the Ericson et al. [39] classification that is to be 6 sectors, and they investigate the vertical level of the impacted canine in five categories (Figure 5), as well as Alqerban et al. [43] considered the measurements of canine angulation (A) To the midline, (B) To the lateral incisor, and (C) to the occlusal plane to evaluate the impacted canine position (Figure 6).

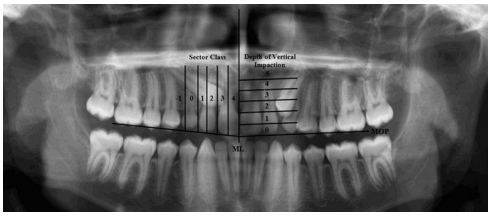

Figure 5: Panoramic radiograph shows sector classification described by Power and Short [42].

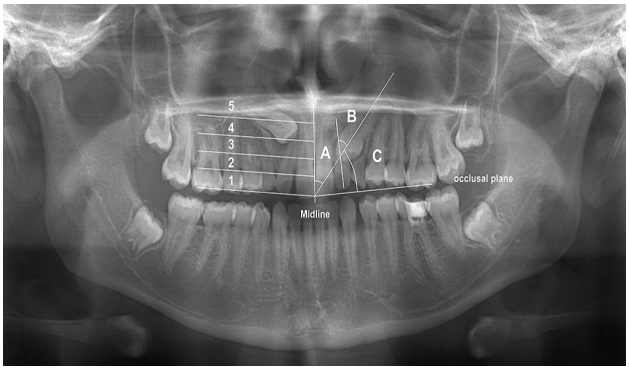

Figure 6: Panoramic image, illustrating the reference lines of the vertical canine location as well as the canine angulation measurements described by Alqerban et al. [43].

Warford et al. [38] select the most superior point of the condyle as skeletal landmarks to define the horizontal baseline. Then, the bicondylar line was drawn and used as a constructed horizontal reference line. The mesioangular measurement formed between the constructed horizontal line and the long axis of the unerupted canine (Figure 7).

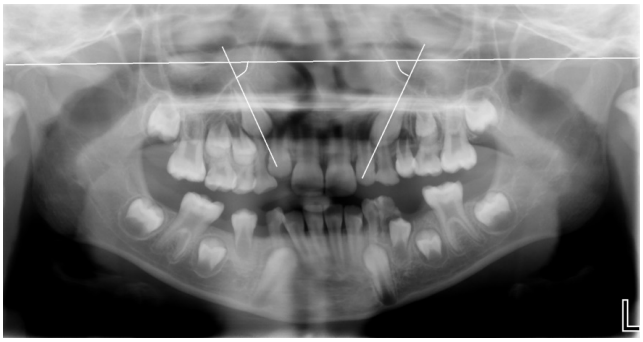

Figure 7: Panoramic radiograph shows the angle formed between the bicondylar line and the long axis of the unerupted canine described by Warford et al. [38].

In (2016) Alqerban et al. [5] suggested a prediction model based on the following parameters: The angle between the long axis of the canine and the first premolar, the perpendicular distance between the canine cusp and the midline, and between the canine cusp and the maxillary plane. This approach could detect these three parameters and might differentiate between early intervention and systematic follow-up of canine impaction.

Additional predictors reported in the literature are the vertical distance from the canine tip to the occlusal plane measured on PR, assessing these variables can aid in a preliminary diagnosis of palatally impacted canines. The vertical rule described by Mc Sherry [44] was used to classify vertical canine displacements [45]. Alqerban et al. [5], found that the vertical distance to be helpful in discriminating between the palatally impacted and non-impacted canines. Malik et al. [46] concluded that the mean vertical distance is approximately 10 mm greater for the impacted than unerupted canines.

A multivariate prognostic approach includes sectors, angles, and linear measurements to estimate the efficiency of interceptive treatment described in the literature. These factors involve the amount of canine crown that horizontally overlaps the adjacent incisor, the vertical height of the canine crown, canine angulation to the midline, and the position of the canine root apex in the horizontal plane. For all of these prognostic factors, the prognosis can range from good to average to poor depending on the position of the impacted canine to the adjacent structures [3,47,48]. Studies by Uribe et al. [49]; Cacciatore et al. [50] and Margot et al. [6] considering the sector location of the impacted tooth was assigned to one of five categories based on the canine crown horizontal overlap of the roots of the adjacent teeth, according to the method described by Ericson et al. [39]. The angle formed by the long axis of the canine with the midline and the angle formed by the long axis of the canine with the occlusal plane. The distance between the cusp tip of the IMC to the occlusal plane.

Nagpal et al. [51] estimated a multivariate method to evaluate IMC depends on image magnification in the panoramic radiography, the height of the cusp tip of the crown of canine in relation to the root of the ipsilateral central incisor (Figure 8) and the mesiodistal position of the impacted canine according to the Erricson et al. [39] sector method. They considered that the differential image magnification as a valuable method to predict the labiolingual position of the maxillary canine on the panoramic radiograph by using two indices; CII (ratio of the widest mesiodistal dimension of impacted Canine/ widest mesiodistal dimension of the ipsilateral central incisor) and CCI (ratio of the widest mesiodistal dimension of impacted Canine/widest mesiodistal dimension of the erupted canine) (Figure 9). They found that the vertical and horizontal restrictions have no value in the recognition of the labiolingual positions of the impacted maxillary canines. The clinical validity of PR in the localization of the impacted canines based on the magnification of the crown size is supported by Alfaleh and Al Thobiani et al. [37 and Bourzgui et al. [52].

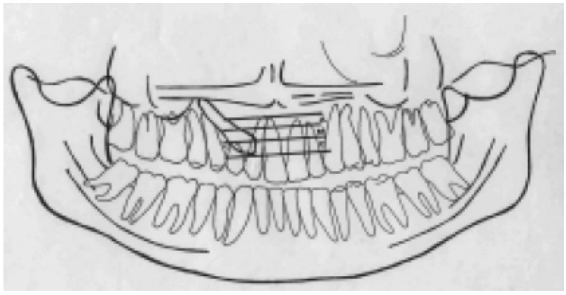

Figure 8: The three vertical zones; A, apical; M, middle; C, coronal.

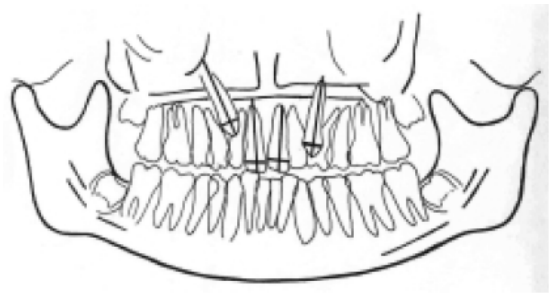

Figure 9: Measurement of widest mesio-distal dimensions of impacted canine and central incisors.

Many authors found that the sector location of the unerupted canine on PR is the most important predictor of eventual impaction. They found about 78–82% of the impacted canines located in sectors II, III, and IV based on sector alone [21,36,38,46]. Other authors, [36,38,41] stated that sector location has a great effect on the prediction of impacted canine more than angulation has. Moreover, Warford et al. [38] and Bourzgui et al. [52] found that angulation did not increase the prediction of canine impaction and the role of angle in predicting impaction is not clinically significant.

In controversy Ericson and Kurol [39], stated that the sector classification was used with moderate to good accuracy to identify a palatal position of IMC; however, it alone does not aid in developing a predictive model during the eruptive stage of the permanent maxillary canine. In addition, Naoumova, et al .[48] stated that both the angle and sector measurements made on PR are good predictors of whether the canine will erupt or not.

Orthodontic considerations

Impacted teeth present a great concern in the orthodontic field because of their potential to complicate orthodontic treatments. The precise localization of the impacted canine can aid to assess the prognosis of orthodontic treatment [37,51]. It is well known that an early diagnosis of canine displacement and prediction of subsequent impaction is important to decrease the patient's need for surgical exposure and prolonged orthodontic treatment with additional costs and various complications [53,54]. An unerupted canine may be displaced from its correct position in three dimensions; horizontally, vertically, or bucco-palatally [45].

It has been reported in the literature that the horizontal overlapping of the MIC according to the sector measurements shows a poor prognosis for canine aligned close to the midline (sectors III and IV). The prognosis is improved as the canine located in sector II, and a good prognosis for canine aligned in sector I [45,54]. Also, the incidence of root resorption in the incisors is increased with a more mesial shift of impacted canine sectors III, IV [54,55]. Alfaleh [37], stated that 64.5% of central incisors with impacted canines located in Sector IV had root resorption, and 9.1% of central incisors with canines located in Sector III were found to have root resorption. Lateral incisor root resorption could be expected in any sector where the IMC cusp tip is located in close

proximity to the lateral incisor root [37]. The presence or absence of root resorption will determine the treatment plan and early diagnosis of impacted canine and root resorption can reduce complications during the treatment [53]. There is a correlation between impaction location and sector location. IMCs found in Sectors I and II tended to be in either mid-alveolus or labial, with a high tendency to be palatally impacted in sectors III and IV [37,51]. Stivaros, et al. [55], suggested that the bucco-palatal position of the canine crown influences the treatment decision, with palatally impacted canines more likely to be exposed, with orthodontic traction to the line of the arch.

Different angulations of the long axis of IMC with adjacent anatomical landmarks have been described in the literature. Regarding the angulation of impacted canines to the mid-sagittal plane, as this angulation increases, a decrease in the prognosis of canine alignment will result. An angulation of >15° considered as a good prognosis, angulation of 16-30° would be a moderate prognosis and an angulation of greater than 31° greatly reduce the chance of eruption [39,42,45]. The interceptive extraction would be economically advantageous to both patients and clinicians and it`s likely to be valuable with 20–30 degrees of angulation and the canine located in sector II-III [45].

In case of severe tooth angulation (<30°) angle, the interceptive extraction is expected not effective and the earlier extraction of the deciduous canine, followed by the orthodontic treatment of aligning the retained canine, might decrease the risk of the canine becoming impacted and minimize the risk of root resorption of the adjacent teeth [48]. Naoumova et al. [48] suggested that the impacted canine angulation with the mid-sagittal plane considered has a minimum effect on the impacted tooth prediction if the tooth located in sectors II and IV. The angulation has potential implications in predicting impaction only in sector II. Malik et al. [46] concluded that every 10° increase in canine angle with the mid-sagittal plane will increase the possibility of its impaction by 1.78 times.

Alqerban et al. [5] stated that the canine angle to the first premolar might be useful to differentiate canine impaction for early intervention or regular follow-up. the higher the probability for impaction occurs in an angle exceeds the 48.2°. Katsnelson et al. [56] attempted to determine the palatal or buccal position of an impacted canine tooth by measuring the angle between the tooth axis and the occlusal plane, if the angle is greater than 65°, there are greater chances of the canine being situated buccally.

The vertical height of the impacted canine crown from the occlusal plane considered as another predicting factor of the canine alignment prognosis. The more apically positioned canine cusp tip means the poor prognosis for alignment. A good prognosis can be expected if the canine cusp tip is located between the cementoenamel junction up to the half root length of the adjacent teeth, and a fair prognosis is expected in case of the canine cusp tip is located at the level of the half root of adjacent teeth and beyond the root apex. A poor prognosis is considered if the canine cusp tip is located above the root apex of adjacent teeth [44,45,55]. It has been suggested that when the position of the canine tip is less than 14 mm above the occlusal plane, orthodontic treatment takes an average of 24 months, and increased to 31 months for vertical displacements beyond 14 mm [14].

The position of the canine root apex in the horizontal plane considered as a prognostic factor for impacted canine alignment. If the apex is located above the normal canine position, the prognosis for alignment is good, if it is above the first premolar region, the prognosis is average, and if it is above the second premolar, the prognosis is poor. The basis for these prognostic indicators has been acknowledged by McSherry et al. [44], Pitt et al. [45] Stivaros et al. [55], and Hosoyama et al. [57]. Naoumova et al. [48] stated a small mesial angle, a long distance from the canine cusp tip to the midline, and a short distance from the canine cusp tip to the maxillary dental arch have been suggested as predictors of a successful outcome.

CONCLUSIONS

It has been reported in the literature

- Proper treatment plan to manage the IMC is essential for esthetic and functional patient requirements.
- Panoramic radiography serves as a reliable indicator to evaluate the IMC in a simple, fast, and widely available imaging modality with a minimum dose of radiation to the patient.
- The multivariate prognostic system considered as a valuable diagnostic method to predict the alignment of IMC depending on its mesiodistal position by the sector classifications, angulation of the tooth long axis with adjacent anatomic structures, the vertical height of the impacted canine from the occlusal plane, and the horizontal position of its the root apex.

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