Original Article

Bilateral maxillary canine impaction with comparable migration track: Prevalence, sociodemographics and radiographic observations

ABSTRACT

Introduction: Canines are perceived as cornerstones of the dental arch and plays an essential role in maintaining the facial coordination. When impacted, these functions are lost. We present the prevalence and radiographic presentation of distinctive bilateral maxillary canine.

Materials and Methods: This was a retrospective study of patients presenting for routine dental treatment between 2018 and 2020 at a dental center, Najran. A total of 2016 panoramic radiographs were screened and all patients with bilateral impacted canines were further screened radiologically using cone beam computed tomography. Data such demographics and presence of bilateral maxillary impacted canines were identified. Data analyzed using IBM SPSS Statistics for IOS Version 25 (Armonk, NY, USA: IBM Corp).

Results: A total of 2016 panoramic radiographs were examined out of which 149 cases were the total impacted canines. Of these, 42 cases were bilateral impacted maxillary canines in comparable migration tract with a prevalence rate of 28.2%. There were 18 males and 24 females with an M: F of 1:1.3. Age ranged from 15 to 75 years with mean age ± standard deviation (27.9 ± 10.6) years. We observed the bilateral impacted canine positions were in relation to the central and lateral incisors in the anterio-posterior plane and the cervical and root portions of the roots of the central and lateral incisors in the inferior-superior plane. We attempted to group them into 3 main types (Types 1-3) with 3 subtypes (Subtypes a-c) each.

Limitations: This a hospital based study and findings may not be generalized. Population based study is which is required to find out the prevalent rate in the community.

Conclusion: These observed positions can be used to predict the favorability or otherwise of orthodontic traction of the impacted bilateral canines.

Keywords: Canine, impaction, migration, transmigration

INTRODUCTION

Maxillary canine is the second most commonly impacted tooth after third molars.[1] The incidence of impacted maxillary canine ranges from 0.92% to 4.3%.[1,2] In the mandible, prevalence of migrated canine was reported to be between 0.35% and 0.44%.[3] Migration is a rare occurrence in the maxilla.[4,5] Tooth migration and impaction in the mandibular and maxillary bone resulting in impaction is a well-documented phenomenon.[5] However, when such migrated tooth crosses the midline then it is termed transmigration.[5] Transmigration is a rare occurrence with prevalence rate of only about 0.31%.[6] There are several

Received: 30-May-2020 **Revised:** 31-May-2020
Accepted: 05-June-2020 **Published:** 09-Jul-2020

Access this article online	
Website: www.orthodrehab.org	Quick Response Code
DOI: 10.4103/ijor.ijor_24_20	

Bandar Alyami, Ramat Oyebunmi Braimah[1]
Department of Preventive Dentistry, Faculty of Dentistry, Najran University, [1]Department of Maxillofacial Surgery, Specialty Regional Dental Center, Najran, Saudi Arabia

Address for correspondence: Dr. Bandar Alyami, Department of Preventive Dentistry, Faculty of Dentistry, Najran University, P. O. Box: 1988, Najran, Saudi Arabia.
E-mail: bsalyami@nu.edu.sa

How to cite this article: Alyami B, Braimah RO. Bilateral maxillary canine impaction with comparable migration track: Prevalence, sociodemographics and radiographic observations. Int J Orthod Rehabil 2020;11:47-53.

factors that could lead to migrated/impacted canine. Two current and most popular (guidance and genetic theories) have been accepted worldwide amongst researchers.[7]

Different terminologies have been used to describe different impaction positions of the canine. Qaradaghi, was the first to use the terms of "kissing Canines" or "Mirror Image" to describe bilateral migrated canines in the mandible.[5] Other authors have reported similar cases in the literature.[8,9] Researchers have used the term "bilateral impacted maxillary canine" to describe cases of canine migration in the maxillary arch.[10,11] Different authors have presented management of bilateral impacted maxillary canines in awkward positions. Previous existing classifications have classified impacted canines based on orthodontics or surgical difficulties.[11-13] This identified clinical entity needs to have a detailed and less cumbersome classification for management, research and to standardize intra and inter examiners variability.

We report the evaluation of panoramic and cone-bean computed tomography (CBCT) radiographs of bilateral impacted maxillary canines with comparable migration tract in a population with strong cultural background and consanguineous marriage that has been linked with many genetic diseases.[14] Additionally, we presented the radiographic observations of this unique clinical entity.

MATERIALS AND METHODS

This was a retrospective study of patients presenting for routine dental treatment between 2016 and 2018 at a Dental Center, Najran kingdom of Saudi Arabia after clearance from the ethical committee review board of the center. Najran is the 10th largest region in the country with majority of the people from a single major family. In addition, the people of Najran have strong cultural background which include consanguineous marriages among this single major family.

All panoramic radiographs with impacted canine were collected and reviewed. Data such as age, gender, types of impacted canine and presence of bilateral impacted maxillary canines were identified and recorded by Consultant orthodontist and Oral and Maxillofacial Surgeon. Those with bilateral impacted maxillary canines where further evaluated by CBCT (Carestream Dosimetry of the 9500 three-dimensional (3D) Cone Beam System, Carestream Dental LLC, 3625, Cumberland Blvd. Ste. 700, Atlanta, GA 30339) which is low dose CBCT combining panorama, cephalometric and 3D. The CBCT was used to identify the exact location of the bilateral canine impactions in relation to the reference points. The observation of the "bilateral impacted maxillary canines" took into consideration not only the positions of the impacted canines but also the reference points which were the maxillary laterals and centrals incisors [Figure 1].

Data was stored and analyzed using IBM SPSS Statistics for IOS Version 25 (Armonk, NY, USA: IBM Corp) and results presented as simple frequencies and descriptive statistics. Pearson Chi-square was used to compare categorical variables. A $P \leq 0.05$ was considered significant.

RESULTS

A total of 2016 panoramic radiographs were examined out of which 149 cases were the total impacted canines. Of these, 42 cases were bilateral impacted maxillary canines with a prevalence rate of 28.2%. Only the 42 cases were analyzed. There were 18 males and 24 females with an M: F of 1:1.3. Age ranged from 15 to 75 years with mean age ± standard deviation (27.9 ± 10.6) years.

This panoramic observation of "bilateral impacted maxillary canines" was centered on the horizontal plane (proximity to the midline) with reference to central and lateral incisors and vertical plane (degree of eruption) with reference to cervical, middle third and apical third of the centrals and lateral incisors. The summary of this panoramic observation is as shown in Figure 2 and grouped as follows;

- Type 1a: Bilateral mesio-angular positioned maxillary canine in relation to the mesial side of the apical third root portion of central incisor either in palatal or labial position [Figure 3a]
- Type 1b: Bilateral mesio-angular positioned maxillary canine in relation to the mesial side of the middle third root portion of central incisor either in palatal or labial position [Figure 3b]
- Type 1c: Bilateral mesio-angular positioned maxillary canine in relation to the mesial side of the cervical third

Figure 1: Schematic diagram showing the impacted canines and the lateral and central incisors as reference points for the new grouping

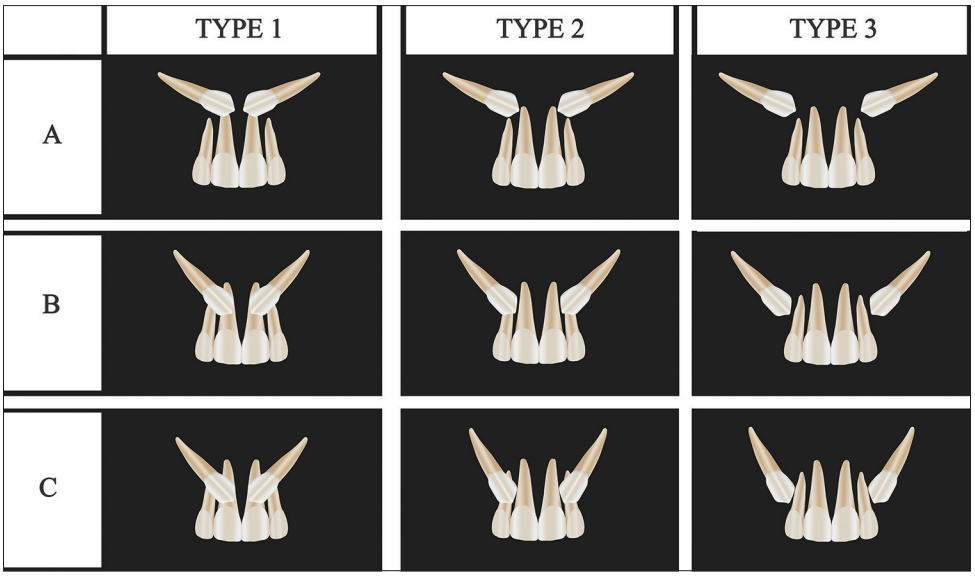

Figure 2: Schematic diagram showing the grouping into 9 types

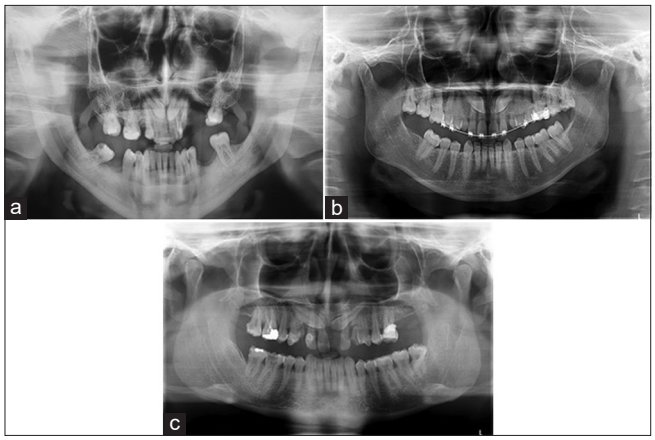

Figure 3: (a) Type 1 (Subtype a): Bilateral mesio-angular positioned maxillary canine in relation to the mesial side of the apical third root portion of central incisor either in palatal or labial position. (b) Type 1 (Subtype b): Bilateral mesio-angular positioned maxillary canine in relation to the mesial side of the middle third root portion of central incisor either in palatal or labial position. (c) Type 1 (Subtype c): Bilateral mesio-angular positioned maxillary canine in relation to the mesial side of the cervical third root portion of central incisor either in palatal or labial position

root portion of central incisor either in palatal or labial position [Figure 3c]

- Type 2a: Bilateral mesio-angular positioned maxillary canine in relation to the distal side of the apical third root portion of central incisor either in palatal or labial position [Figure 4a]
- Type 2b: Bilateral mesio-angular positioned maxillary canine in relation to the distal side of the middle third root portion of central incisor either in palatal or labial position [Figure 4b]
- Type 2c: Bilateral mesio-angular positioned maxillary canine in relation to the distal side of the cervical third root portion of central incisor either in palatal or labial position [Figure 4c]
- Type 3a: Bilateral mesio-angular positioned maxillary canine in relation to the distal side of the apical third root portion of lateral incisor either in palatal or labial position [Figure 5a]
- Type 3b: Bilateral mesio-angular positioned maxillary canine in relation to the distal side of the middle third root portion of lateral incisor either in palatal or labial position [Figure 5b]
- Type 3c: Bilateral mesio-angular positioned maxillary canine in relation to the distal side of the cervical third root portion of lateral incisor either in palatal or labial position [Figure 5c].

Figure 6a and b displays CBCT of a 22 years old female and 24 year old male showing the axial, occlusal view, coronal and sagittal cuts of bilateral canine impaction in palatal and buccal positions respectively.

There were more Type 2 (subtypes b and c) cases (10 (23.8%) and 11 (26.2%) respectively) and followed by Type 3 (subtype c) and Type 1 (subtype a) with (5 (11.9%)) cases each. Only 1 case (2.4%) were classified as Type I (subtype c). Other distributions were as shown in Table 1. There was no statistically significant difference when gender was compared with the radiographic observations ($\chi^2 = 8.081$, $df = 8$, $P = 0.426$). Age group (15–30) years presented with the highest frequency of bilateral impacted maxillary canines 29 (69.0%), while age group 41–60 years presented with the least frequency of 2 (4.8%) cases [Table 2]. This however, did not attain any statistical significance when age group was compared with types of bilateral impacted maxillary canines ($\chi^2 = 44.233$, $df = 32$, $P = 0.74$). Table 3 showed the distribution of the bilateral impacted maxillary

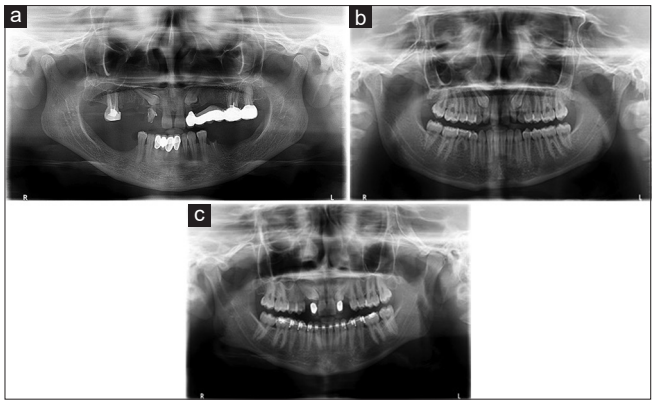

Figure 4: (a) Type 2 (Subtype a): Bilateral mesio-angular positioned maxillary canine in relation to the distal side of the apical third root portion of central incisor either in palatal or labial position. (b) Type 2 (Subtype b): Bilateral mesio-angular positioned maxillary canine in relation to the distal side of the middle third root portion of central incisor either in palatal or labial position. (c) Type 2 (Subtype c): Bilateral mesio-angular positioned maxillary canine in relation to the distal side of the cervical third root portion of central incisor either in palatal or labial position

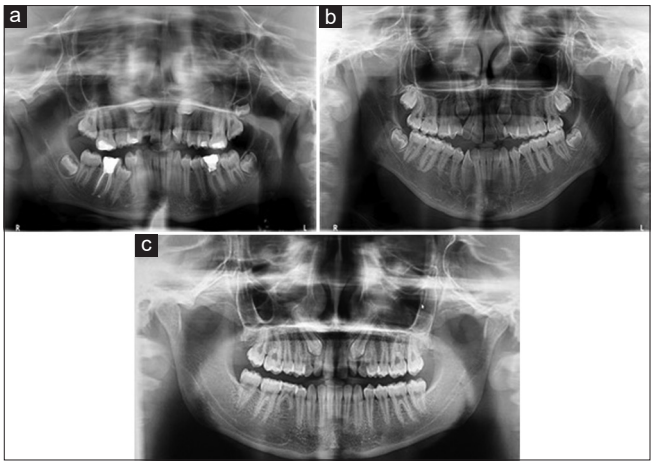

Figure 5: (a) Type 3 (Subtype a): Bilateral mesio-angular positioned maxillary canine in relation to the distal side of the apical third root portion of lateral incisor either in palatal or labial position. (b) Type 3 (Subtype b): Bilateral mesio-angular positioned maxillary canine in relation to the distal side of the middle third root portion of lateral incisor either in palatal or labial position. (c) Type 3 (Subtype c): Bilateral mesio-angular positioned maxillary canine in relation to the distal side of the cervical third root portion of lateral incisor either in palatal or labial position

canines according to their positions (labial/palatal). Out of the 42 cases, 33 (78.6%) were in palatal position, while only 9 (21.4%) were in labial position with a significant difference of $P = 0.021$ [Table 3].

DISCUSSION

Canines are considered to be the cornerstones of the dental arch. They play an essential role in maintaining the facial coordination and functional competence.[15] Due to the lack of space, maxillary canines are frequently impacted and this has been reported to be second to maxillary and mandibular third molars impaction.[16,17] Because of prolonged intra-bony embedment usually 12 years after the tooth germ formation at 24 weeks intra uterine life, the tooth germ of maxillary canines is subjected to adverse forces from developing adjacent anatomical structures such as orbital cavity, nasal cavity and maxillary sinus.[18]

Maxillary canine impaction is more commonly seen than mandibular canine impaction. However, transmigration is more commonly reported in the mandibular arch as it rarely occurs in the maxilla.[5,19] This is because the mandibular canine has long root and greater cross-sectional area of the mandibular symphysis and conical crown.[20] Etiology of this rare clinical entity is still elusive. Researchers have proposed circumstances such as ectopic growth of the tooth bud, premature loss/retention of a primary tooth, lack of eruption space and disproportionate crown length. Other factors such as genetic, endocrine disorders and trauma have also been suggested as etiological factors.[21] All these etiological factors result in loss of guidance for the erupting canine, thereby causing them to migrate within the bones.[22] Najran, a city in the southern region of Saudi Arabia have strong cultural background which include consanguineous marriages among a single major family. This consanguinity has been implicated as a major risk factor in etiologies of many genetic conditions including tooth impaction.[14,21]

Table 1: Distribution of types of bilateral impacted maxillary canines according to patients' gender

	Gender		Total (%)
	Male (%)	Female (%)	
Type 1 (Subtype a)	4 (9.5)	1 (2.4)	5 (11.9)
Type 1 (Subtype b)	2 (4.8)	0 (0.0)	2 (4.8)
Type 1 (Subtype c)	0 (0.0)	1 (2.4)	1 (2.4)
Type 2 (Subtype a)	0 (0.0)	2 (4.8)	2 (4.8)
Type 2 (Subtype b)	4 (9.5)	6 (14.3)	10 (23.8)
Type 2 (Subtype c)	5 (11.9)	6 (14.3)	11 (26.2)
Type 3 (Subtype a)	1 (2.4)	2 (4.8)	3 (7.1)
Type 3 (Subtype b)	2 (4.8)	1 (2.4)	3 (7.1)
Type 3 (Subtype c)	2 (4.8)	3 (7.1)	5 (11.9)
Total	20 (47.6)	22 (52.4)	42 (100.0)

$\chi^2=8.081$, df=8, $P=0.426$

In the mandible, bilateral transmigration is very atypical with an occurrence of only 9%.[23] None has been reported in the maxilla. Current study has reported 42 cases of impacted canine in the maxilla assuming the "bilateral impacted maxillary canines position" with a prevalence rate of 28.2%. Although, a prevalence rate of 8% has been reported in the literature,[24] literature search yielded one study in the kingdom that reported a prevalence of bilateral maxillary canine impaction to be 22.3% in Jazan, a southern city.[25] Jazan and Najran cities

Table 2: Distribution of types of bilateral impacted maxillary canines with age group of patients

	Age groups					Total (%)
	11-20 (%)*	21-30 (%)	31-40 (%)	41-50 (%)	51-60 (%)	
Type 1 (Subtype a)	1 (2.4)	2 (4.8)	2 (4.8)	0 (0.0)	0 (0.0)	5 (11.9)
Type 1 (Subtype b)	0 (0.0)	1 (2.4)	1 (2.4)	0 (0.0)	0 (0.0)	2 (4.8)
Type 1 (Subtype c)	0 (0.0)	1 (2.4)	0 (0.0)	0 (0.0)	1 (0.9)	1 (2.4)
Type 2 (Subtype a)	2 (4.8)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	2 (4.8)
Type 2 (Subtype b)	5 (11.9)	2 (4.8)	3 (7.1)	0 (0.0)	0 (0.0)	10 (23.8)
Type 2 (Subtype c)	4 (9.5)	7 (16.7)	0 (0.0)	0 (0.0)	0 (0.0)	11 (26.2)
Type 3 (Subtype a)	0 (0.0)	0 (0.0)	2 (4.8)	1 (2.4)	0 (0.0)	3 (7.1)
Type 3 (Subtype b)	0 (0.0)	1 (2.4)	2 (4.8)	0 (0.0)	0 (0.0)	3 (7.1)
Type 3 (Subtype c)	0 (0.0)	3 (7.1)	1 (2.4)	0 (0.0)	1 (2.4)	5 (11.9)
Total	12 (28.6)	17 (40.5)	11 (26.2)	1 (2.4)	1 (2.4)	42 (100.0)

*Minimum age of the group is 15 years. χ^2=44.233, df=32, P=0.74

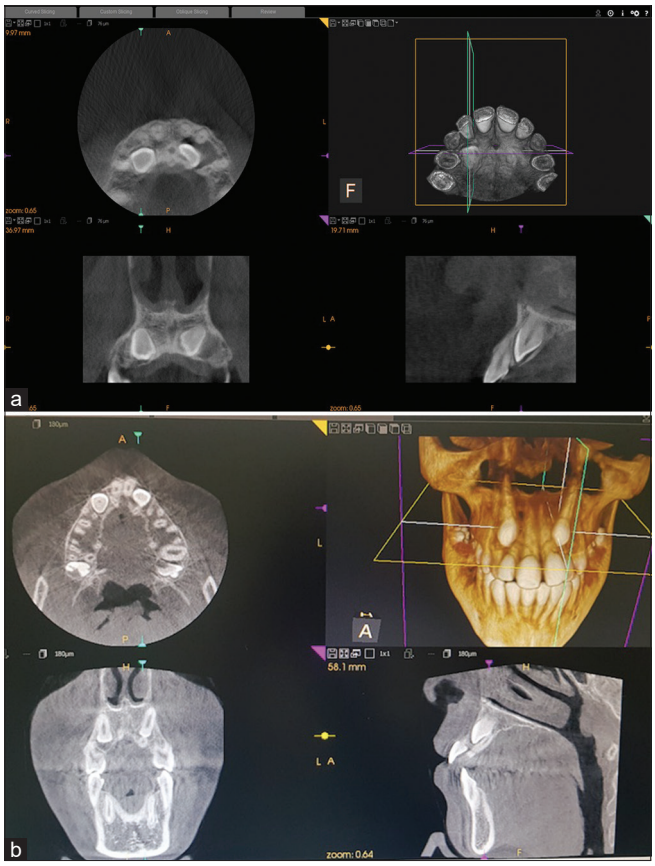

Figure 6: (a) Cone-beam computed tomography of a 22-year-old female showing the axial cut, occlusal view, coronal and sagittal cuts of bilateral canine impaction in the palatal position. (b) Cone-beam computed tomography of a 24-year-old male showing the axial cut, occlusal view, coronal and sagittal cuts of bilateral canine impaction in the buccal position

are both located in the southern region of the kingdom of Saudi Arabia with similar prevalence rates compared to the present study (22.3% [Jazan] and 28.2% [Najran] respectively). More studies identifying these unique clinical situations are necessary from other regions in the kingdom.

Although, Yamamoto *et al*.[18] have classified impacted maxillary canines and first premolars into 9 types, his classification was based on unilateral impacted canines. The radiographic observation is unique in the fact that it was based on bilateral impacted canines assuming an exceptional position in relation to the centrals and laterals in the maxilla.

Table 3: Distribution of types of bilateral impacted maxillary canines according to position

	Position		Total (%)
	Labial (%)	Palatal (%)	
Type 1 (Subtype a)	2 (4.8)	3 (7.1)	5 (11.9)
Type 1 (Subtype b)	0 (0.0)	2 (4.8)	2 (4.8)
Type 1 (Subtype c)	1 (2.4)	0 (0.0)	1 (2.4)
Type 2 (Subtype a)	2 (4.8)	0 (0.0)	2 (4.8)
Type 2 (Subtype b)	0 (0.0)	10 (23.8)	10 (23.8)
Type 2 (Subtype c)	2 (4.8)	9 (21.4)	11 (26.2)
Type 3 (Subtype a)	0 (0.0)	3 (7.1)	3 (7.1)
Type 3 (Subtype b)	0 (0.0)	3 (7.1)	3 (7.1)
Type 3 (Subtype c)	2 (4.8)	3 (7.1)	5 (11.9)
Total	9 (21.4)	33 (78.6)	42 (100.0)

χ^2=18.026, df=8, *P=0.021 (Statistically significant)

In addition to panoramic views, the identified cases were further evaluated for the positions of the impacted canine using CBCT (Carestream Dosimetry of the 9500 3D Cone Beam System, Carestream Dental LLC, 3625, Cumberland Blvd. Ste. 700, Atlanta, GA 30339) which is low dose CBCT combining panorama, cephalometric and 3D imaging. This modality has been used by clinicians to localize impacted canines precisely. However, high cost and radiation exposure have restricted its routine use, although the model used in this current study uses low dose radiation with concentration in dental arches only.[26,27] The accurate localization of the impacted canine tooth plays a key role in determining the appropriate surgical access and the accurate direction of orthodontic forces application.[28]

The "kissing" or "mirror image" canines reported in the mandible has a female predilection.[19] Similarly, female predilection was reported in the present study. Canine

impaction generally has been reported to be more common in the females because the skull, maxilla, and mandible are smaller in women than in men. Although, no studies supporting this position, anecdotal findings believe there are jaw discrepancies between individuals with/without impaction.[18] No specific age group has been reported in the literature, however, we found more cases of bilateral impacted maxillary canines in the 21–30 and 31–40 years of age. It can be reasoned that these age brackets are usually periods of self-identification with young adults seeking dental treatments especially malocclusion.

It has been reported that most of these conditions are accidental findings on routine panoramic radiographs for endodontics and/or orthodontic purposes.[15] In the current study, most patients presented for endodontic and restorative purposes wherein during routine panoramic radiographs these impacted canines were discovered.

Researchers have reported that management of transmigration/migration of canines should be based on the stage of development of the tooth, the position of the tooth and whether there are symptoms associated with the tooth.[15,29] Since they are usually asymptomatic, it has been suggested that mandibular bilateral impacted canines can be observed for any changes but surgical extraction is highly recommended when associated with symptoms or any form of pathology.[15] Several management options have been reported in the literature which include: surgical exposure with orthodontic realignment in labially placed canine, surgical repositioning and transplantation when enough space is available and orthodontic realignment and re-contouring of the crown.[22,29]

Pitt *et al*.[30] have concluded from their study based on regression analysis that horizontal position (degree of overlap of lateral and central incisors), age of patient, vertical height and bucco-palatal position, in downward order of rank, are the factors which determine the difficulty of canine alignment. Based on the present observations, as horizontal angulations of impacted canines towards the midline increases (i.e., from Types 3-1 respectively), the poorer the prognosis of orthodontic traction/alignment and the higher the tendency for surgical extraction.[31] Furthermore, studies have shown that, the higher the impacted canine cusp tip is to the occlusal plane, the poorer the prognosis for orthodontic traction.[32] When the cusp tip rest against the apical third of the adjacent incisor root (Subtype a), the poorer the prognosis. A fair prognosis is anticipated when the cusp tip rest at the level of half root length (Subtype b), while a good prognosis is anticipated when the cusp tip is at the cemento-enamel junction (Subtype c) of the adjacent incisor tooth. Based on these two scenarios, Type 1 (Subtype a) has the poorest prognosis in terms of treatment difficulty while Type 3 (Subtype c) has the best treatment prognosis with orthodontic traction.

CONCLUSION

We report 42 cases of bilateral impacted maxillary canines with a prevalence rate of 28.2%. The observed radiographic positions were grouped into 9 types. This observation was based on the cusp tip of the crown of the impacted canine, their proximity to lateral and central incisors and relationship to their roots (apical, middle or cervical thirds). The treatment difficulty index was anticipated poor for Type 1 (Subtype a) and best for Type 3 (Subtype c). Furthermore, this observation was based on both panoramic radiographs which is readily available and CBCT. Other factors such as age of patient, degree of rotation and surgical exposure difficulty should be employed in the final comprehensive evaluation prior to categorizing the treatment difficulties of this radiographic observations.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

REFERENCES

1. Roberts-Harry D, Sandy J. Orthodontics. Part 10: Impacted teeth. Br Dent J 2004;196:319-27.
2. Watted N, Abu-Hussein M. Prevalence of impacted canines in Arab Population in Israel. Int J Public Health Res 2014;2:71-7.
3. Aydin U, Yilmaz HH, Yildirim D. Incidence of canine impaction and transmigration in a patient population. Dentomaxillofac Radiol 2004;33:164-9.
4. Umashree N, Kumar A, Nagaraj T. Transmigration of mandibular canines. Case Rep Dent 2013;2013:697671.
5. Qaradaghi IF. Bilateral transmigration of impacted mandibular canines: Report of two cases and review. Rev Clín Pesq Odontol 2010;6:271-75.
6. Alaejos-Algarra C, Berini-Aytes L, Gay-Escoda C. Transmigration of mandibular canines: Report of six cases and review of the literature. Quintessence Int 1998;29:395-8.
7. Sajnani AK, King NM. The sequential hypothesis of impaction of maxillary canine – A hypothesis based on clinical and radiographic findings. J Craniomaxillofac Surg 2012;40:e375-85.
8. Batra P, Duggal R, Parkash H. Canine ectopia: Report of two cases. J Indian Soc Pedod Prev Dent 2003;21:113-6.
9. Ahmad SA, Ahmad SS, Poddar RN, Masood R. Bilateral transmigration of mandibular canines: A case report and review of literature. J Dent Med Sci 2013;3:56-9.
10. Mesotten K, Naert I, van Steenberghe D, Willems G. Bilaterally impacted maxillary canines and multiple missing teeth: A challenging adult case. Orthod Craniofac Res 2005;8:29-40.
11. Arvystas M. Diagnosis, sequencing, and management of bilateral

horizontally positioned, palatally impacted maxillary canines with closed surgical exposure and immediate continuous light orthodontic traction. J World Fed Orthod 2014;3:81-90.
12. Chapokas AR, Almas K, Schincaglia GP. The impacted maxillary canine: A proposed classification for surgical exposure. Oral Surg Oral Med Oral Pathol Oral Radiol 2012;113:222-8.
13. Kau CH, Pan P, Gallerano RL, English JD. A novel 3D classification system for canine impactions–the KPG index. Int J Med Robot 2009;5:291-6.
14. Bener A, Hussain R, Teebi AS. Consanguineous marriages and their effects on common adult diseases: Studies from an endogamous population. Med Princ Pract 2007;16:262-7.
15. Tiwari RV, Mathew P, Jose Y, Tiwari H, David J. Kissing canines: Impacted & migrated: Case report. Int J Appl Dent Sci 2018;4:22-4.
16. Shapira Y, Kuftinec MM. Intrabony migration of impacted teeth. Angle Orthod 2003;73:738-43.
17. Camilleri S, Scerri E. Transmigration of mandibular canines – A review of the literature and a report of five cases. Angle Orthod 2003;73:753-62.
18. Yamamoto G, Ohta O, Tsuda Y, Tanaka A, Nishikawa M, Inoda H, *et al*. A new classification of impacted canines and second premolars using orthopantomography. Asian J Oral Maxillofac Surg 2003;15:31-7.
19. Mupparapu M. Patterns of intraosseous transmigration and ectopic eruption of mandibular canines: Review of literature and report of nine additional cases. Dentomaxillofac Radiol 2002;31:355-60.
20. Auluck A, Nagpal A, Setty S, Pai KM, Sunny J. Transmigration of impacted mandibular canines – A report of four cases. J Can Dent Assoc 2006;72:249-52.
21. Bishara SE. Impacted maxillary canines: A review. Am J Orthod Dentofacial Orthop 1992;101:159-71.
22. Kumar S, Urala AS, Kamath AT, Jayaswal P, Valiathan A. Unusual intraosseous transmigration of impacted tooth. Imaging Sci Dent 2012;42:47-54.
23. Joshi MR. Transmigrant mandibular canines: A record of 28 cases and a retrospective review of the literature. Angle Orthod 2001;71:12-22.
24. Kharbanda OP. Orthodontics Diagnosis and Management of Malocclusion and Dentofacial Deformities. 1st ed.. India: Elsevier; 2009.
25. Alhammadi MS, Asiri HA, Almashraqi AA. Incidence, severity and orthodontic treatment difficulty index of impacted canines in Saudi population. J Clin Exp Dent 2018;10:e327-34.
26. Ludlow JB. A Manufacturer's Role in Reducing the Dose of CBCT Examinations: Dosimetry of the 9500," a Technical Report Submitted to Dentomaxillofacial Radiology. Atlanta: University of North Carolina, School of Dentistry; 2014.
27. Ludlow JB. Dosimetry of 9000 3D Small FOV CBCT and Panoramic Unit. Chapel Hill, NC: University of North Carolina School of Dentistry; 2009.
28. Manne R, Gandikota C, Juvvadi SR, Rama HR, Anche S. Impacted canines: Etiology, diagnosis, and orthodontic management. J Pharm Bioallied Sci 2012;4:S234-8.
29. Kunjumon RM, Nausheen E, Nalin AS, George GB, Raj PR. Ectopic eruption of a transmigrated mandibular canine: A rare case report. IJSS Case Rep Rev 2015;2:17-9.
30. Pitt S, Hamdan A, Rock P. A treatment difficulty index for unerupted maxillary canines. Eur J Orthod 2006;28:141-4.
31. Stivaros N, Mandall NA. Radiographic factors affecting the management of impacted upper permanent canines. J Orthod 2000;27:169-73.
32. McSherry PF. The assessment of and treatment options for the buried maxillary canine. Dent Update 1996;23:7-10.