Official Dental Journal of Suez Canal University
DENTAL SCIENCE Updates
Print ISSN 2636-3836
Online ISSN 2636-3844
www.dsujournals.ekb.eg
DSU — Vol. 5, No. 1, March (2024) — PP. 77:86

EVALUATION OF THE POSITION AND TREATMENT DIFFICULTY OF IMPACTED MAXILLARY CANINE USING CONE BEAM COMPUTED TOMOGRAPHY: A RETROSPECTIVE STUDY

Sara Salah Saleh Fehed[1], Waleed Refaat El-Nagar[2], Asmaa Youssry Abdallah[3], Walaa El-Sayed Elgameay[4]

DOI: 10.21608/dsu.2024.196527.1163
Manuscript ID: DSU-2302-1163

KEYWORDS

Cone beam computed tomography, impacted canines, virtual aligned canines, 3D imaging, unilateral impaction, severity

- E-mail address: ortho_sara@dent.suez.edu.eg

1. Demonstrator at Orthodontic Department, Faculty of Dentistry, Suez Canal University.
2. Professor of Orthodontics, Faculty of Dentistry, Suez Canal University.
3. Associate professor of Oral and Maxillofacial Radiology department, Faculty of dentistry, Suez Canal University.
4. Associate professor of Orthodontics, Faculty of Dentistry, Suez Canal University.

ABSTRACT

Introduction: Impaction of the permanent maxillary canines is a serious dental development disorder that affects about 3% of the general population. Its final position in the occlusion is critical for the completion of the arch form, functional occlusion, dental symmetry, and harmony. **Aim:** The aim of the present study was to evaluate the impacted maxillary canine location on 3D images and to determine positional components associated with impaction severity that may affect treatment difficulty. **Material and methods:** The current study included 40 CBCT scans of 40 unilateral impacted canines where several angular and linear measurements on the reconstructed panoramic, axial, sagittal, and coronal views were measured and then based on the angle between the impacted canine and their proposed post-treatment position, the sample was divided to three impaction severity groups, group 1: Mild (IMPC/VAC <30º), group 2: Moderate (IMPC/VAC 30º-55º), and group 3: Severe (IMPC/VAC >55º). **Results:** Severity of impacted canines increased when their cusp tips were close to midline distance<4mm ,and the vertical distance to the maxillary occlusal plan was >14mm, when their root apices were far from the dental midline a distance>23mm, and from the skeletal midline a distance>16mm. Severity of the impacted canine was associated with increased angulation IMPC/VAC>45º, IMPC/midline>45º, and IMPC/PL>120º. **Conclusions:** Cone beam computed tomography images enable thorough localization of impacted canines and their relationship to neighboring anatomical structures, the use of virtual aligned canine in the recent study is a reliable and applicable method that can be used in future research.

INTRODUCTION

Impacted maxillary permanent canines (**IMPCs**) are commonly encountered in the orthodontic field, after third molars, maxillary canines are the most frequently impacted teeth, with a prevalence in the range 0.9–3.0%, depending on the population examined[(1)]. Several complications associated with the impacted maxillary permanent canine had been well documented including absence of dentoalveolar symmetry in case of unilateral impaction, absence of canine protected occlusion, resorption of the adjacent permanent incisors or premolars, internal or external resorption of the impacted canine, cyst formation around the un erupted canine, flattened nasolabial fold, and referred pain[(2)].

Radiographic evaluation of the impacted maxillary permanent canines is a critical component in the diagnosis of the condition. Three-dimensional **(3D)** imaging comes to the forefront in the diagnosis and treatment decision of the canine impaction. Several studies had been published that support and proved the superiority of the use of CBCT for accurate localization of IMPCs and related root resorption of adjacent incisors[3–6]. Cone beam computed tomography **(CBCT)** changed 2D-based diagnosis and treatment planning of impacted canines in 27% of the evaluations[7].

The treatment of impacted canine is multidisciplinary and is associated with prolonged treatment time and increased costs. Previous studies have highlighted the radiographic parameters that affect the prognosis of IMPCs. The most influencing of such parameters according to the literature were; the labio-palatal position of the IMPC in the alveolus[8–11], unilateral or bilateral[8,12–14], the sector position of the IMPC[2,8,10,15], the lateral distance of IMPC cusp tips and root apices to midline[16,17], the vertical distance of IMPC to occlusal plane[13,16,18], and the angulation of the IMPC to the midline[17,19,20].

A detailed assessment of the impacted canine's location, angulation and orientation is essential for planning treatment; therefore, the aim of the present study was to assess the pretreatment position of the impacted canine using 3D CBCT to determine the difficult canine impactions that may affect treatment procedures.

MATERIALS AND METHODS

This study was conducted on forty CBCT radiographs of patients with unilateral impacted maxillary permanent canines collected from the archives of the Oral Radiology department, Faculty of Dentistry, Suez Canal University after the approval of the REC (Research Ethics Committee) of the Faculty No/261/2020. The CBCT radiographs included in the present study were of good quality and sufficient field of view to fully cover the maxilla. Exclusion criteria were radiographs with limited field of view, or low resolution that precluded accurate measurements, presence of odontogenic tumors or cysts around the IMPCs, cases with radiographic signs of orthodontic treatment, craniofacial anomalies, or syndromes.

Radiographic evaluation:

OnDemand 3D™ software (version 1.0, Cybermed Inc., Seoul, South Korea) was used in this study for image analysis and to obtain the following measurements**.**

1. From reconstructed panoramic view the following parameters were obtained (Figure 1):

a. Impacted maxillary permanent canine/virtual aligned canine angle (IMPC/VAC) (Figure1.B), defined as the angle between the long axis of the IMPC and the virtual position of the normally aligned canine between the lateral incisor and first premolar. The virtual aligned canine is therefore defined as the proposed post-treatment position of the impacted canine in the arch. The maxillary occlusal plane was first drawn as the line from the mesiobuccal cusp of the maxillary first molar to the incisal edge of the maxillary central incisor. The VAC was then set at 11° angulation to a line perpendicular to the maxillary occlusal plane at area of the canine, The long axis of the IMPC was represented by a line passing from the cusp tip to the root apex (Figure1.A).

b. The angulation of the impacted maxillary permanent canine to dental midline (α angle): The dental midline was first drawn which was

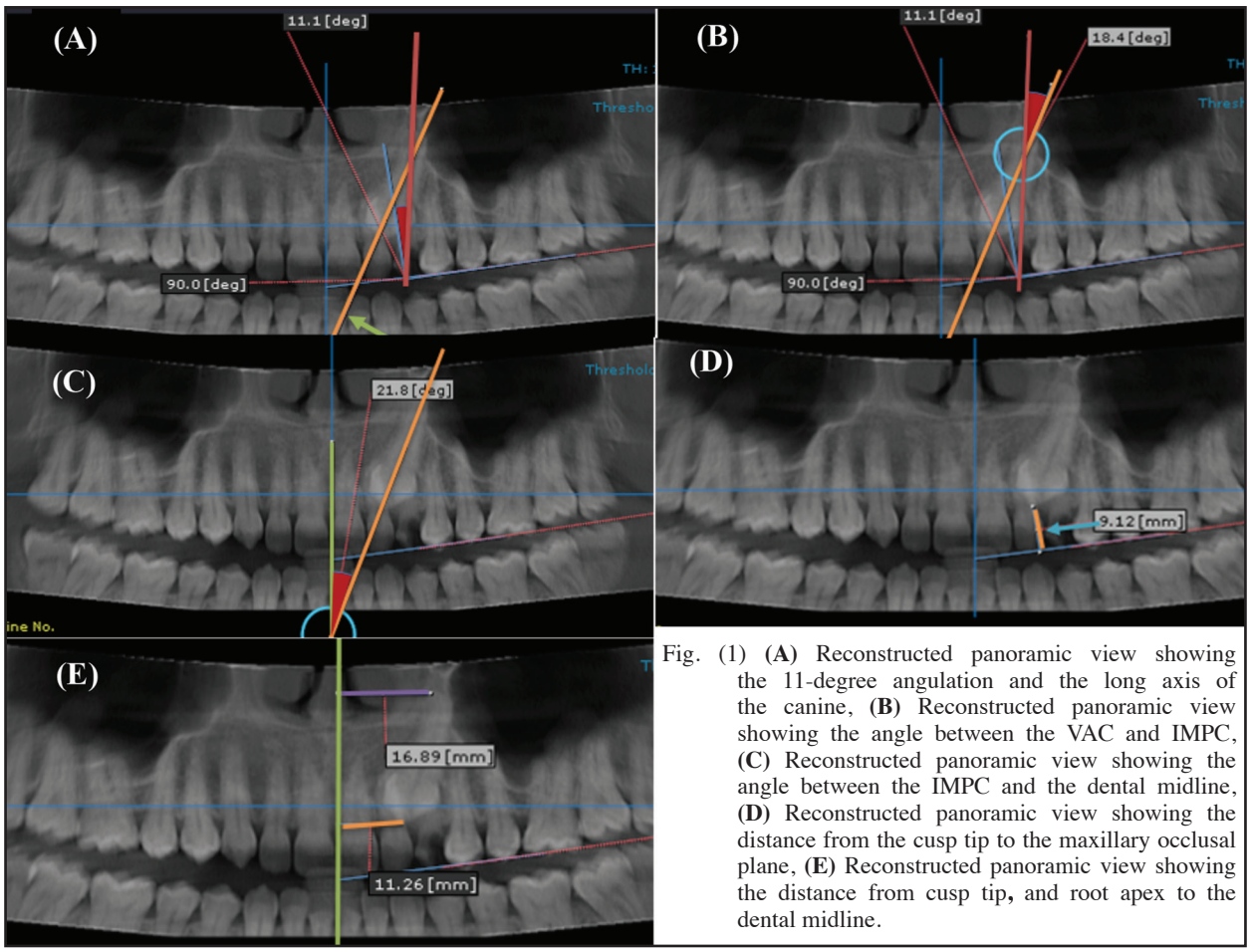

Fig. (1) **(A)** Reconstructed panoramic view showing the 11-degree angulation and the long axis of the canine, **(B)** Reconstructed panoramic view showing the angle between the VAC and IMPC, **(C)** Reconstructed panoramic view showing the angle between the IMPC and the dental midline, **(D)** Reconstructed panoramic view showing the distance from the cusp tip to the maxillary occlusal plane, **(E)** Reconstructed panoramic view showing the distance from cusp tip, and root apex to the dental midline.

represented by a vertical line passing between the central incisors (Figure1.C). Then, α angle was measured as the angle between the long axis of the IMPC and the midline.

c. Linear distance of impacted maxillary permanent canine cusp tip to maxillary occlusal plane (DTO), was measured as a line from the canine cusp tip dropped perpendicular to the maxillary occlusal plane[21] (Figure1.D).

d. Linear distances between cusp tip and root apex of the impacted maxillary permanent canine to the dental midline were obtained, where the canine cusp tip and root apex of the IMPC were intersected perpendicular to the dental midline and measured. (Figure1.E).

2. From the axial view the following parameters were obtained (Figure2.A, B):

a. Cusp tip and root apex of impacted canine deviations from skeletal midline: Distances between the cusp tip (Figure2.A) and root apex (Figure2.B) of the IMPC were measured to the skeletal midline The skeletal midline was identified by the following landmarks on the radiographs: intermaxillary suture, incisive foramina, anterior nasal spine, and nasal septum.

3. From the coronal view the following angle was obtained (Figure2.C):

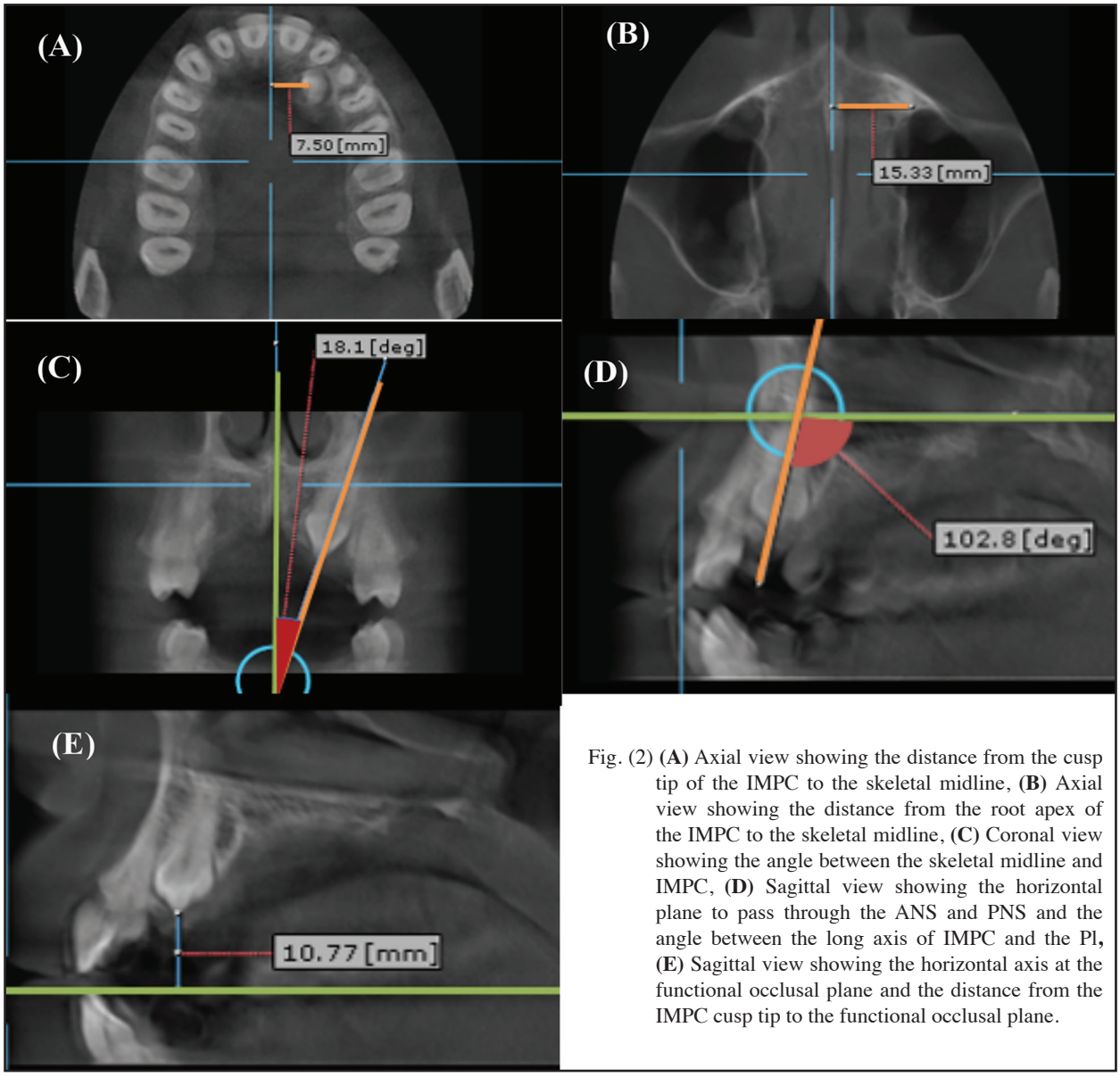

Fig. (2) **(A)** Axial view showing the distance from the cusp tip of the IMPC to the skeletal midline, **(B)** Axial view showing the distance from the root apex of the IMPC to the skeletal midline, **(C)** Coronal view showing the angle between the skeletal midline and IMPC, **(D)** Sagittal view showing the horizontal plane to pass through the ANS and PNS and the angle between the long axis of IMPC and the Pl**, (E)** Sagittal view showing the horizontal axis at the functional occlusal plane and the distance from the IMPC cusp tip to the functional occlusal plane.

a. The impacted maxillary permanent canine angulation to the skeletal midline: obtained as the angle between a line passing through the midline of the maxilla and the long axis of the canine (a line passing through the canine cusp and the canine apex) (Figure2.C).

4. From the sagittal view the following parameters were obtained: (Figure2.D, E):

a. Impacted maxillary permanent canine angulation to palatal plane (Pl): The landmarks used to identify the palatal plane were the anterior nasal spine (ANS) and posterior nasal spine (PNS), the long axis of the canine was drawn and the angle between the IMPC and Pl was measured (Figure2.D).

b. Cusp tip of the impacted maxillary permanent canine to the functional occlusal plane:

The functional occlusal plane was drawn as a line extending from the incisal edge of the mandibular central incisor and the most superior occlusal edge of the mandibular first permanent molar[22], then the vertical distance between the canine cusp tip and the functional occlusal plane was obtained (Figure2.E).

Sample Grouping:

Based on angle IMPC/VAC obtained from reconstructed panoramic view, the cutoff point of the angle was set at 30º, which is approximately third the distal angulation of the normal positioned canine angulation (11º) to complete horizontal impacted canine at an angle of (90º)[17], the cases were divided into three impaction severity groups:

Group 1: Mild impaction severity (IMPC/VAC <30º),

Group 2: Moderate impaction severity (IMPC/VAC 30º-55º), and

Group 3: Severe impactions (IMPC/VAC >55º).

Statistical analysis:

The statistical analysis was carried out using computer software Statistical Package for Social Science **(SPSS)**. Data was collected, checked, revised, and organized in tables and figures using Microsoft Excel 2016. Data was subjected to outliers' detections and normality testing using Shapiro-Wilk and Kolmogorov-Smirnov. Difference between parametric data was performed using independent samples t-test.

Statistical assessments comprised ANOVA for group comparisons, the difference between mild, moderate, and severe groups in various measured parameters were presented as mean and standard deviation. Differences were assessed by one-way ANOVA followed by Duncan's multiple range test in parametric data to measure specific differences between pairs of means. Statistical significance was set at $P \leq 0.05$.

RESULTS

All measurements on CBCT radiographs included in the study were repeated at least 14 days after the initial assessment by the same examiner to determine intra-observer reliability, intra-spectator dependability inside consistency evaluated Cronbach's alpha and ICC at 0.05 level. Accordingly, high intra-observer reliability was seen between R1 and R2 (reading 1 and reading 2). The ICC between R1 and R2 showed a high agreement between them ranging between 0.898 to 0.981 in all measured variables. Moreover, Cronbach's alpha also revealed high agreement between R1 and R2 ranging between 0.946 to 0.990.

Results of the current study are listed in (table1). Comparison between the three study groups showed that the highest clinically significant differences between groups were related to α-angle, cusp tip to maxillary occlusal plane, root apex to dental midline in the reconstructed panoramic view, IMPC/skeletal midline in the coronal view, apex deviation in the axial view, and IMPC/skeletal midline in the sagittal view, while cusp tip to skeletal midline showed a significant difference in the axial view, and less significant difference in the reconstructed panoramic view, while cusp tip to functional occlusal plane in the sagittal view showed non-significant difference between groups.

In addition, the mean values regarding root apex to dental midline in reconstructed panoramic view, root apex, and cusp tip deviation in the axial view, showed resemblance in moderate and severe impaction groups with no significant difference

between them but they both differed from mild impaction group.

Based on the angle between the IMPC and their future treated position, or as referred as the "virtual aligned canine position", results of the current study can be summarized in the following points:

1. Severely impacted canines showed mesial or medial position of their cusp tips close to the midline (distance<4mm).
2. Severely impacted canines showed distal position of their apices to the dental midline (distance>23mm), and to skeletal midline (distance >16mm).
3. Severely impacted canines showed increased angulation of the IMPC to VAC (IMPC/VAC>45º)
4. Severely impacted canines showed increased angulation of the IMPC to midline in reconstructed OPG and coronal view (IMPC/midline>45º).
5. Severely impacted canines showed high IMPC/PL angle>120º, the severity of this angle reflected the difficulty of repositioning the root buccally during orthodontic treatment and indicated a more difficult path of eruption.
6. Sever impaction showed higher vertical distance to occlusal plane (DTO>14mm).

Table (1) *Comparison between the three groups regarding the various measured parameters.*

	Mean ± SD			**ANOVA**	
	gp1: Mild (n=15)	**gp2: Moderate (n=20)**	**gp3: Severe (n=5)**	**F**	**Sig.**
Reconstructed panoramic view					
IMPC/VAC	17.80±7.01 c	40.85±5.96 a	59.29±5.91 b	198.7	<.001***
α-angle	20.40±10.34 c	43.45±6.93 b	60.91±8.03 a	108.4	<.001***
Cusp tip to occlusal plane	7.04±2.25 c	10.42±3.15 b	14.37±1.94 a	30.5	<.001***
cusp tip to midline	9.85±2.92 a	6.55±5.98 a	6.57±5.78 a	4.1	0.021*
root apex to midline	18.23±3.84 b	23.39±5.68 a	26.35±7.26 a	12.3	<.001***
Coronal view					
IMPC/midline	13.37±7.90 c	26.81±17.38 b	44.22±21.03 a	17.1	<.001***
Axial view					
Cusp tip deviation	9.01±3.15 a	5.49±5.15 b	4.42±4.49 b	6.9	0.002**
Apex deviation	12.78±2.08 b	15.70±2.98 a	16.86±3.69 a	12.4	<.001***
Sagittal view					
IMPC/PL	108.06±9.12 c	121.54±10.59 b	135.78±10.97 a	32.4	<.001***
Cusp to functional occlusal plane	8.49±5.55 a	10.25±3.77 a	10.37±5.04 a	1.4	0.265 ns

P value for comparisons between severity groups, statistical significance was set at P ≤ 0.05.
**Means less significant difference. **Means significant difference. ***Means highly significant difference.*
Ns means non-significant difference.

DISCUSSION

Impacted teeth, particularly IMPCs, are major challenges in the orthodontic field because of their potential to complicate orthodontic procedures. In the dental arch, the permanent canine is a powerful tooth that plays a key role in occlusion, lateral articulation motions, and aesthetics[9]. As a result, a well-positioned canine in the dental arch is one of the therapeutic goals in every treatment plan.

Radiographic examination has always been an important part of diagnosing an impacted canine. Recently, three-dimensional imaging had taken the lead in radiographic examination of the impacted canine[23]. Several published studies have supported and proved the superiority of the use of CBCT for accurate localization of IMPCs and related root resorption of adjacent incisors[4–6]. therefore, further emphasizing the diagnostic benefit of 3-D imaging over traditional 2-D imaging approaches[24–26].

From this perspective, the present study was conducted for the purpose of localization and determination of positional components associated with impaction severity using CBCT to determine which diagnostic parameters greatly affect the treatment decision based on the severity of the impacted canine.

To individualize the severity of canine impaction for each case, the present research used the angulation between IMPC to its' proposed post-treatment position for grouping the study sample to three groups, based on the differences in IMPC/VAC angle as obtained from reconstructed panoramic view, to determine the reliability and applicability of this method for severity assessment of IMPC in different cases in the future[17]. The diagnostic parameters used in the current study were chosen precisely after thorough reviewing the literature to select the most influencing parameters affecting the severity level and subsequently affecting treatment decision. According to previous studies, such parameters are; the sector position of the IMPC[8–10,15], the lateral distance of IMPC cusp tips and root apices to midline[17,27], the vertical distance of IMPC to occlusal plane[17,22,28], the angulation of the IMPC to the midline[9,17,20], to the virtual aligned canine[17], and to the occlusal plane[22,29]. Accordingly, the choice of parameters was included in our study.

Results of the current study showed excellent intra-examiner reliability for almost all angular and linear parameters used for analysis of impacted canine severity, hence reflecting the reproducibility of the method described to locate IMPC using CBCT.

Regarding the parameters assessed from the reconstructed panoramic view, IMPC/VAC angle was significantly different between all three groups, which was in accordance with a previous study conducted be Zeno and Ghafari[17]. Results of both studies showed that severity of the impaction was correlated to angulation >45°.

In the present study, α-angle showed highly significant difference between groups and the severity of impaction was found to be associated with angulation>45°, which was in accordance with the study conducted by Zeno and Ghafari et al.[17]. The angulation of an unerupted canine to midline (α-angle) had been shown to influence the likelihood of impaction, risk of resorption, and the duration of treatment[30]. According to Bazargani et al.[31], α-angle was able to explain 54% of the variation in treatment duration, the adjusted treatment time rose by 0.19 months for every degree of higher -angulation.

In the current study, DTO showed a high statistically significant difference between groups, where severity of impacted canine increased when DTO was >14mm as measured from reconstructed panoramic and sagittal views. Such results were again in accordance with those of Zeno and Ghafari[17], as well as the results of Stewart et al.[12] who found that DTO higher than 14mm was seen in severe impaction cases, and was associated with increased treatment duration. On the other hand, Fleming et al.[16] could not identify a statistically significant link between vertical distance and treatment duration (p=0.065), the weakness in their investigation was the limited sample size.

The horizontal distance of the root apex of IMPC to midline was measured twice, the first was to dental midline from reconstructed panoramic view, and the second was to skeletal midline from the axial view. Regarding the distance to dental midline, the severity of impaction was found to be related to distance>23mm. Similarly, Zeno and Ghafari[17] found that distance>20mm was related to the severe impaction group with a highly significant difference. For the distance to skeletal midline, the results of the current study showed that distance>16mm was associated with increased impaction severity, however, the results of Zeno and Ghafari[17] showed statistically non-significant relation between the distance of root apex to midline and the severity of impaction.

Similarly, in the coronal view, the angle of the IMPC/midline showed highly significant difference between groups with which was again in agreement with the results of the previously mentioned study by Zeno and Ghafari [17]. Our results reflect that in severe impaction groups, the deviation of the IMPC crown in the mesio-distal horizontal direction increased, where most of the cases were distally tipped, mild impaction cases showed a more normal mesio-distal tip value than moderate and severe impaction groups.

In the sagittal view, IMPC/Pl angle showed a highly significant difference between groups, such results were in accordance with previous studies conducted by Zeno and Ghafari [17], and Ross et al [27] revealing that the increase in this angle (IMPC/PL>120º) was correlated to increased impaction severity. From a clinical standpoint, the severity of this angle reflects the difficulty of repositioning the root buccally during orthodontic treatment which makes it difficult to achieve correct angulation in the third order, thus compromising aesthetics [27].

The limitations of the current study included the relatively small sample size. In addition, no orthodontic treatment was performed to clinically align impacted canines to confirm the effect of the assessed parameters on the actual severity of IMPC. Lack of sufficient data in the literature concerning virtual aligned canine was another limitations

CONCLUSIONS

1. Severity of canine impaction is not only a factor of canine cusp position, but also the root apex position in mesiodistal and labiolingual position is of high diagnostic effect since root movement during canine alignment may result in root resorption of the canine itself or the adjacent teeth especially if the distance of root movement needed is large.
2. The virtual position of the normally aligned canine helped in assessing the severity of canine impaction and is therefore recommended for the determination of treatment difficulty.

REFERENCES

1. Kau CH, Pan P, Gallerano RL, English JD. A novel 3D classification system for canine impactions - The KPG index. Int J Med Robot Comput Assist Surg. 2009;5(3): 291–6.
2. Iancu Potrubacz M, Chimenti C, Marchione L, Tepedino M. Retrospective evaluation of treatment time and efficiency of a predictable cantilever system for orthodontic extrusion of impacted maxillary canines. Am J Orthod Dentofac Orthop. 2018;154(1):55–64.
3. Serrant PS, Mcintyre GT, Thomson DJ. Localization of ectopic maxillary canines — is CBCT more accurate than conventional horizontal or vertical parallax ? J Orthod. 2014;41(1):13–8.
4. Farokh-Gisour E, Salahi-Ardakani M-A, Motaghi R. Localization of Impacted Maxillary Canines and Root Resorption of Neighbouring Latral Incisor Using Cone Beam Computed Tomography. Int J Med Res Heal Sci. 2016;5(8):187–90.
5. Sarıkır Ç, Alkurt MT, Değerli Ş, Altunkaynak B, Peker İ. Comparison of panoramic radiography and cone-beam computed tomography for qualitative and quantitative measurements regarding localization of permanent impacted maxillary canines. Acta Odontol Turc. 2017;34(1):1–7.
6. Dağsuyu İM, Kahraman F, Okşayan R. Three-dimensional evaluation of angular, linear, and resorption features of maxillary impacted canines on cone-beam computed tomography. Oral Radiol. 2018;34(1):66–72.
7. Haney E, Gansky SA, Lee JS, Johnson E, Maki K, Miller AJ, et al. Comparative analysis of traditional radiographs and cone-beam computed tomography volumetric images in the diagnosis and treatment planning of maxillary impacted canines. Am J Orthod Dentofac Orthop. 2010;137(5):590–7.
8. Arriola-Guillén LE, Aliaga–Del Castillo A, Ruíz-Mora GA, Rodríguez-Cárdenas YA, Dias–Da Silveira HL. Influence of maxillary canine impaction characteristics and factors associated with orthodontic treatment on the duration of active orthodontic traction. Am J Orthod Dentofac Orthop. 2019;156(3):391–400.
9. Grisar K, Fransen J, Smeets M, Hoppenreijs T, Ghaeminia H, Politis C, et al. Surgically assisted orthodontic alignment of impacted maxillary canines: A retrospective analysis of functional and esthetic outcomes and risk factors for failure. Am J Orthod Dentofac Orthop. 2021;159(6):e461–71.
10. Amuk M, Amuk NG, Ozturk T. Effects of root – cortex relationship , root shape , and impaction side on treatment duration and root resorption of impacted canines. Eur J Orthod. 2021;43(5):508–15.
11. Alhummayani FM, Mustafa ZA. A new guide using CBCT to identify the severity of maxillary canine impaction and predict the best method of intervention. J Orthod Sci. 2021;10:3.
12. Stewart JA, Heo G, Glover KE, Williamson PC, Lam EWN, Major PW. Factors that relate to treatment duration for patients with palatally impacted maxillary canines. Am J Orthod Dentofac Orthop. 2001;119(3):216–25.
13. Schubert M, Baumert U. Alignment of Impacted Maxillary Canines: Critical Analysis of Eruption Path and Treatment Time. J Orofac Orthop. 2009;70(3):200–12.
14. Nieri M, Crescini A, Rotundo R, Baccetti T, Cortellini P. Factors affecting the clinical approach to impacted maxillary canines: A Bayesian network analysis. Am J Orthod Dentofac Orthop. 2010;137(6):755–62.
15. Kocyigit S, Oz AA, Bas B, Arici N, Karahan S. Are age and radiographic features effective on orthodontic alignment of palatally impacted maxillary canines? a retrospective study. Eur Oral Res. 2019;53(3):132–6.
16. Fleming PS, Scott P, Heidari N, Dibiase AT. Influence of radiographie position of ectopic canines on the duration of orthodontic treatment. Angle Orthod. 2009;79(3):442–6.
17. Zeno KG, Ghafari JG. Palatally impacted canines: A new 3-dimensional assessment of severity based on treatment objective. Am J Orthod Dentofac Orthop. 2018;153(3):387–95.
18. Baccetti T, Crescini A, Nieri M, Rotundo R, Pini Prato GP. Orthodontic treatment of impacted maxillary canines: an appraisal of prognostic factors. Prog Orthod. 2007;8(1):6–15.
19. Grisar, K., Piccart, F., Al-Rimawi, A. S., Basso, I., Politis, C., & Jacobs R. Three dimensional position of impacted maxillary canines : Prevalence , associated pathology and introduction to a new classification system. Exp Dent Res. 2019;5(1):19–25.
20. Shin H, Park M, Chae JM, Lee J, Lim HJ, Kim BC. Factors affecting forced eruption duration of impacted and

labially displaced canines. Am J Orthod Dentofac Orthop. 2019;156(6):808–17.

21. Sajnani AK, King NM. Diagnosis and localization of impacted maxillary canines: comparison of methods. J Investig Clin Dent. 2013;4(4):252–6.
22. Miresmaeili A, Basafa M, Mahvelati Shamsabadi R, Farhadian N, Moghymbeigi A, Mollabashi V. Treatment decision analysis for palatally-displaced canines based on orthodontists' opinion and CBCT. Int Orthod. 2017;15(4):625–39.
23. Harrell WE. Three-dimensional diagnosis & treatment planning: The use of 3D facial imaging & ConeBeam CT (CBCT) in orthodontics & dentistry. Australas Dent Pract. 2007;18:102–13.
24. Wriedt S, Jaklin J, Al-Nawas B, Wehrbein H. Impacted upper canines: examination and treatment proposal based on 3D versus 2D diagnosis. J Orofac Orthop. 2012;73(1): 28–40.
25. Alqerban A, Hedesiu M, Baciut M, Nackaerts O, Jacobs R, Fieuws S, et al. Pre-surgical treatment planning of maxillary canine impactions using panoramic vs cone beam CT imaging. Dentomaxillofacial Radiol. 2013;42(9):20130157.
26. Alqerban A, Jacobs R, Keirsbilck P-J van, Aly M, Swinnen S, Fieuws S, et al. The effect of using CBCT in the diagnosis of canine impaction and its impact on the orthodontic treatment outcome. J Orthod Sci. 2014;3(2):34.
27. Ross G, Abu Arqub S, Mehta S, Vishwanath S, Tadinada A, Yadav S, et al. Estimating the 3- D location of impacted maxillary canines: A CBCT- based analysis of severity of impaction. Orthod Craniofac Res. 2023;26(1):81–90.
28. Bazargani F, Magnuson A, Dolati A, Lennartsson B. Palatally displaced maxillary canines: factors influencing duration and cost of treatment. Eur J Orthod. 2013; 35(3):310–6.
29. Malik D e. S, Fida M, Sukhia RH. Correlation between radiographic parameters for the prediction of palatally impacted maxillary canines. J Orthod. 2019;46(1):6–13.
30. Power SM, Short MBE. An Investigation into the Response of Palatally Displaced Canines to the Removal of Deciduous Canines and an Assessment of Factors Contributing to Favourable Eruption. Br J Orthod. 1993; 20(3):215–23.
31. Bazargani F, Magnuson A, Dolati A, Lennartsson B. Palatally displaced maxillary canines: Factors influencing duration and cost of treatment. Eur J Orthod. 2013; 35(3):310–6.