

ORIGINAL ARTICLE

Comparison between KPG Index and OPG Measurements: Predicting Orthodontic Treatment Duration and Difficulty Level in Impacted Canines

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ABSTRACT

Objective: To compare 2D (Orthopantomogram) and 3D KPG index based on (CBCT) measurements to predict the treatment duration and difficulty level of orthodontic treatment for canine impaction.

Study Design: Cross sectional analytical study.

Place and Duration of Study: Orthodontic Department, Rehman College of Dentistry, Peshawar from 4th September, 2017 till 8th August, 2020.

Materials and Methods: OPG and CBCT (Cone beam computed tomography) records of 49 impacted canines were scored for both 2D and 3D indexes. KPG index measurements were taken for each impacted canine in x, y, z planes, scored from 0- 5 and summed up. Based on these scores, each impaction was classified into two categories, Easy to Moderate (0–14), Difficult to very Difficult (15 -30). Following 2D measurements were taken on OPG, cusp tip distance to the occlusal plane, cusp tip position relative to adjacent lateral incisor, and inclination of canine relative to midline. Comparisons were made using Chi square test and Spearman's correlation was used to find any association between 2D and 3D methods. P values ≤ 0.05 were considered significant.

Results: 68.8% of the impacted canines were found on the palatal side with a female (73.5%) predilection. The 2D Ericson and Kuroi analysis and Stewart's indexes showed a significant difference when compared with 3D KPG index ($p= 0.001$) and a moderate correlation ($r=0.47$). Comparison between the 2D indexes showed an insignificant difference ($p=0.90$) and a weak correlation ($r=0.26$).

Conclusion: 3D KPG index measurements, compared to the 2D indexes, showed a significant difference and a moderate correlation. Therefore, KPG index can be used in place of 2D indices to accurately locate, determine the difficulty level and treatment duration of orthodontic treatment of impacted canines.

Key Words: *Canine Impaction, CBCT (Cone beam Computed tomography), KPG Index.*

Introduction

Impacted canine is a frequently seen anomaly after third molar impaction.^{1,2} Its general prevalence ranges between 0.3%-0.9% with a female predilection.² Prevalence of canine impaction varies with ethnicity and hence, its reported to be 5% in Pakistani population.³ Almost 85% of the impactions are found to be on palatal side.³⁻⁵

Determining the precise location of impacted teeth is crucial not only for the definite diagnosis but also for determining the management difficulty

estimation and related treatment duration.⁶ Up till now, Conventional 2D radiological methods, Orthopantomogram (OPG), cephalometric radiography, and intraoral occlusal or periapical X-rays were being used to serve the diagnostic purpose.⁷⁻⁹ 2D radiographs rely on 'Buccal Object Rule' to determine the position of canine. Separate set of radiographs is needed when the direction of X-ray beam is changed.⁶ Diagnostic accuracy and validity of 2D methods can be underestimated due to limitations such as distortion, radiographic films volume reduction related patient positioning and tissue superimposition.^{6,9-11}

Due to recent advances in diagnostic technology, CBCT is being considered a gold standard in dental radiology.¹⁰ Today, CBCT is preferred over 2D radiological methods due to its reliability and accuracy.⁹ Currently, CBCT is being used in various fields including maxillofacial, dental implantology and orthodontics.^{7,11,12} Alqerban et al compared

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CBCT and OPG and revealed, CBCT to be more sensitive in precisely locating the position of impacted canine and also the root resorption of adjacent teeth.^{9,13}

Conventionally, 2D indexes were used to localize the impacted teeth. Stewart and Ericson and Kuroi.¹⁰ proposed classification methods for localization of impacted canine. KPG index based on CBCT was introduced in 2009. This was the first index that helped to understand the spatial relationship of the impacted tooth in 3D space.⁶ Due to the reported reliability, validity, and accuracy of KPG index, it can be used as a standard for the diagnosis and prediction of treatment difficulty.^{2,7,10,14}

Numerous studies have been conducted in the past to determine the influence of various CBCT software's, settings for field of view (dosage variation), voltage and exposure time on the scoring of KPG index.⁹ Various studies have compared Newton 3G, Kodak 9500, Planmeca voxel and found the reproducibility of KPG index was not influenced if dimensions and slice thickness were kept similar.^{7,14,15}

Domenico et al conducted a study to evaluate level of agreement and predict difficulty levels between 2D and 3D KPG index and suggested, 2D indices were sometimes discordant while 3D (KPG index) could solve that conflict.¹⁴

According to our knowledge no such comparison has yet been reported in Pakistan between classical 2D measurements (Stewart's and Ericson and Kuroi's) and KPG index analysis.

The purpose of this study was to compare the 2D vs 3D KPG index from the CBCT scans taken from CBCT apparatus (CS 9000) to predict the difficulty level of impacted canine and treatment duration. The results of this study would help the orthodontist to precisely plan the time duration and biomechanical issues related to the diagnosis and management phase based on the difficulty level of impacted canine.

Materials and Methods

This cross-sectional study was conducted at Orthodontic Department, Rehman College of Dentistry (RCD), Peshawar, from 4th September, 2017 till 8th August, 2020. Sample size was calculated as 49 per group using G power calculator (effect size=0.75, α - error=0.05, power=0.95). Data were collected using non-probability consecutive sampling technique after the ethical approval from (Reference

NO: 2020-08-050) Research Committee of (RCD). Informed consent was taken from the patients for the use of records in research or academic activity.

CBCT scans (CS 9000) with 49 impacted canines were collected and assessed for the patients who were referred by the orthodontist to have CBCT for the diagnostic evaluation of the impacted canines for both maxillary and mandibular regions. All unilateral, bilateral maxillary and mandibular canine impaction were included in the study. Patients with dentofacial deformities, syndromes, traumatic injuries jaws/teeth, were excluded from the study.

The images were acquired with Carestream (CS 9000) CBCT scanner at 60 -90 kV, scan time of 4 – 16 seconds, Field of view (FOV 50-37mm) and voxel size (76 ×76× 76 mm). Images were analyzed using CS 3600 3D imaging software. The impacted canine was manipulated in, X (Mesio distal), Y (Vertical), and Z (Labiolingual) planes. The software's measurement tool provided the milli metric data to classify the position of canine using KPG Index. The KPG index rated the canine impactions (cusp and root tips). The scores were based on the distance from ideal position in x, y and z planes. Six measurements were taken per tooth ranging from 0 to 5. The cumulative scores later were classified into 4 difficulty categories, Easy (0–7), Moderate (8–14), Difficult (15–19), and Extremely Difficult (20+). Four categories were reduced to two categories, Easy-moderate category (0–14) and a difficult-very difficult category (15–30) to compare 2D indexes with 3D KPG index.¹⁴ (Figure I)

The OPG, s was reconstructed using the same CBCT apparatus (CS 9000), Scanning. We identified three different angular and linear measurements on OPG. Based on Stewart's analysis, vertical (d-distances) from the cusp tip to the occlusal plane was taken.¹⁴ Measurement less and greater than 14 mm were associated with short and long duration of treatment respectively. (Figure II A) Based on Ericson and Kuroi analysis, position of canine in mesio-distal dimension with the adjacent tooth (lateral incisor) was assessed.¹⁴ Position of canine distal to lateral incisor corresponding sectors 1 and 2 were related to short duration and mesial to lateral incisor corresponding to sectors 3 and 5 were related to long duration. (Figure II B) According to Crescini canine inclination (α -angle) with the line drawn vertically

between the central incisors was measured.¹⁴(Figure IIC)

Statistical analysis was performed using IBM SPSS v.20 (Chicago, Ill). Chi square test, Cohen's Kappa and Spearman's Correlation was used to compare and correlate 2D and 3D KPG methods, respectively. Coefficient values was not relied on when P value was >0.05.P value ≤0.05 were considered significant.

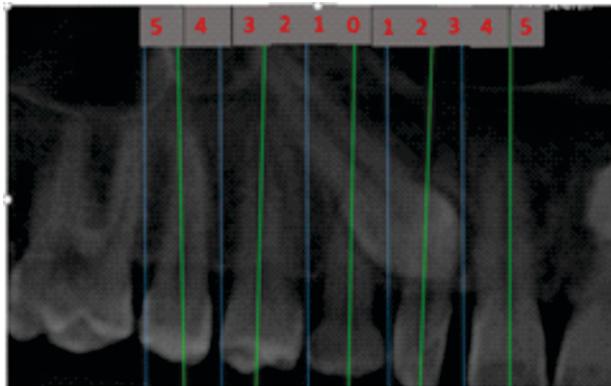


Fig 1: (A)

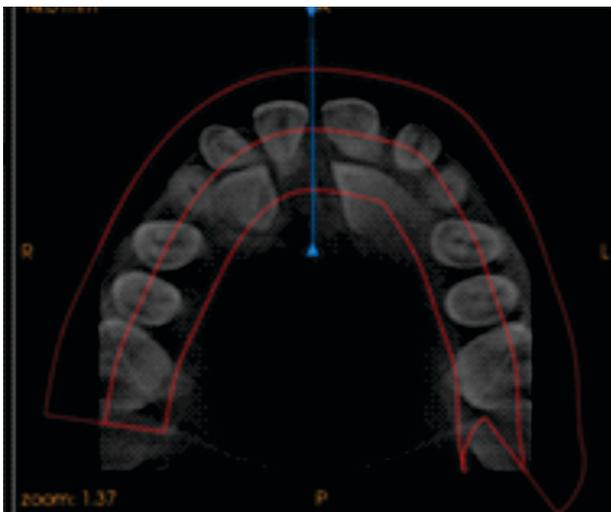


Fig 1: (B)

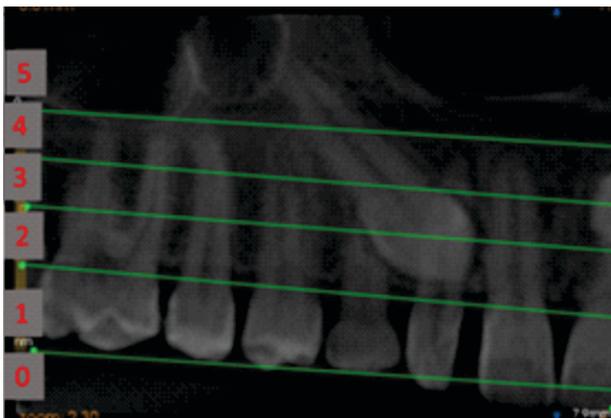


Fig 1: (C)

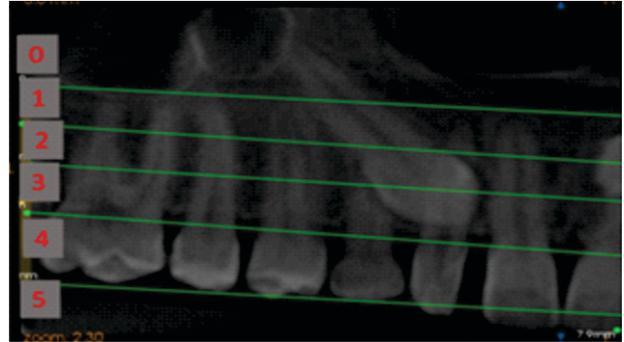


Fig 1: (D)

Figure 1: KPG index scoring 18 years old female patient with Right maxillary canine impaction. (A) Panoramic reformatted CBCT view showing impacted canine root and cusp tip (scored 3 & 3 respectively). (B) Axial cut from CBCT with occlusal reference line showing cusp and root tip in z axis (scored 3 and 3 respectively). (C and D) Panoramic reformatted CBCT view showing Impacted canine in y axis cusp and root tip (scored 2 & 0 respectively). Cumulative score KPG index=3+3+2+0+3+3=14 representing Moderate category.



Fig 2: (A)



Fig 2: (B)

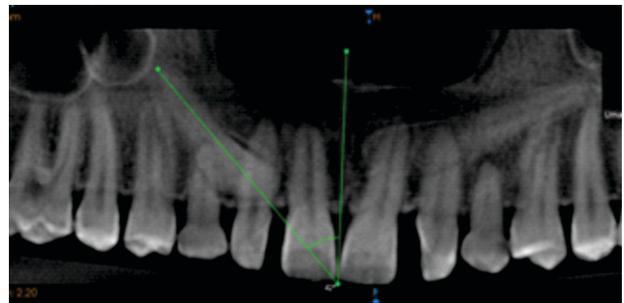


Fig 2: (C)

Figure: 2 (A) Vertical distance taken from canine cusp tip to 90 degree to occlusal palne (upper first molar to upper central incisor). In this example 10.4mm , that corresponds to shorter treatment duration according to Stewart .

(B) Mesial and distal position of impacted canine with respect to the lateral incisor. In this example canine is mesially positioned. In this example it corresponds to difficult treatment according to Ericson and Kurool.

(C) α-angle (canine inclination with line drawn between central incisors. In this example α-angle is 42

Results

Our study was conducted on 49 impacted canines from 44 patients. The sample included 36(73.5%) females and 13(26.5%) males with a mean age of 16.02 years ± 3.96 years. Most of the canine impactions were on the palatal 68.8 % side (Palatal vs Buccal 31.9%) had an equal distribution on right and left sides. The mean value of the canine impaction angle with the midline was 34.6 ±14.7.

In Ericson and Kurool analysis, impacted canines were mostly (73.5%) mesial to the lateral incisors (mesial vs distal 36.5%). In Stewart analysis most of the impacted canines 41 (83.7%) were found to be less than 14mm (d-distance) from the occlusal plane. Means and frequency distribution of KPG, Stewarts and Ericson and Kurool analysis are shown in (Table I).

Ericson and Kurool analysis showed more (73.5%) mesially positioned impacted canines with respect to the lateral incisors (mesial vs distal 36.5%). Measurements of Stewart's analysis revealed the (d-distance) for 41 (83.7%) impacted canines to be less than 14mm from the occlusal plane.

Comparison between 3D KPG index and 2D (Ericson and Kurool analysis and Stewart's measurements) methods, showed a significant difference (p = 0.001). Both 2D indices (Ericson and Kurool analysis and Stewart's) were only moderately correlated with the KPG index(r=0.47) Table II, Table III.

Comparison between the 2D methods (Ericson and Kurool analysis and Stewart's measurements) showed an insignificant difference and a weak correlation (r=0.26) (Table IV).

Discussion

CBCT due to its accuracy and reliability is being used extensively in dentistry for diagnosis, visualization, and precise assessment of canine location.^{2,9} The aim

Table I: Means and frequency distribution of KPG, Stewarts and Ericson and Kurool Analysis

KPG analysis	Easy to difficult 26 (53.1%)	Difficult to very difficult 23(46.9%)
Stewart’s analysis	Short Duration 41 (83.7%)	Long Duration 8 (16.3 %)
Ericson and Kurool analysis	Difficult 36(73.5%)	Easy 13 (26.5%)

Table II: Showing Comparison Between KPG Index Vs Ericson and Kurool Analysis

KPG index	Ericson and Kurool analysis		P value	r value
	Easy N=13	Difficult N=36		
Easy to moderate	12(24.4%)	14(28.5%)	0.001*	0.473
Difficult to very difficult	1(2.04%)	22(44.8%)		

P <= 0.05* R= Spearman's Correlation **

Table III: Showing Comparison Between KPG Index and Stewart's Analysis

KPG index	Stewart’s analysis		P value	r value
	Short duration N=40	Long duration N=8		
Easy to moderate	26(53.0%)	0(0%)	0.001*	0.470
Difficult to very difficult	15(30.6%)	8(16.3%)		

Table IV: Comparison Between Ericson and Kurool Analysis and Stewart's Measurements

		Stewart’s		P value	r
		short duration N=40	Long duration N=8		
Ericson and Kurool	Easy	13(26.5%)	0(0%)	0.90	0.265
	difficult	28(57.1%)	8(16.3%)		

P <= 0.05* R= Spearman's Correlation **

of our study was to compare 2D (Ericson and Kurool and Stewart's analysis) with 3D KPG canine impaction index to determine impaction difficulty factor and orthodontic treatment duration of the impacted canines. We found a significant difference and a moderate correlation in measurements between 3D KPG index and 2D indexes.

We chose 3D KPG index as a standard to compare with the 2D (Ericson and Kurool and Stewart's) indexes, due to its reliability, validity, and accuracy in prediction of treatment difficulty and treatment duration.^{2,7}

In our study, the impactions were predominately found in females and palatal side with an equal distribution on right and left sides. This corroborates with previous studies, showing female to male ratio to be 2:1.^{2,3,16-18} The gender differences may be attributed to the smaller jaw size in females and aesthetic consciousness.^{16,19,20} Dina M et al in their study reports equal distribution on right and left sides. In literature, this pattern has been considered as a general feature of the malformation with no specific scientific evidence.¹⁹

In our study, based on the Ericson and Kuroi analysis, most of the impacted canines were found mesial to the lateral incisors (sector 4 and 5). Arriola G et al showed similar results²⁰ and suggested, presence of impacted canines in sector 4 and 5 in comparison to sector 1,2 and 3, could affect not only the management approaches, biomechanical planning but also the duration of canine traction.²⁰ Similarly, Cuc Thi et al reported palatal canine impactions to be frequently found in sector 3, 4 and 5 compared to the labial impactions and a significant relationship was observed in their study between the root resorption with the impacted canines found in Sector 4 and 5.⁸ Literature suggests that normally the eruption path of canines is in the mesial direction but later after 9 years of age due to guidance from the lateral incisors, shape of maxilla, roots of other teeth and genetic control, canines change their path of eruption (position) to vertical. If the canine does not upright or stays in the mesial position it adds to the difficulty factor.²¹

In current study, in Stewart's analysis lateral incisor was closer to the occlusal plane (d-distance) in most of the cases. Stewart JA et al concluded in their study, if the d-distance was less or greater than 14 mm, duration of orthodontic treatment would be approximately 23.8 months and 31.1 months respectively.^{14,21} It has also been suggested that every 1 mm of distance of the cusp tip of the impacted canine from the occlusal plane needed approximately one more week of orthodontic traction.²²

According to 3D KPG index, in our study most of the impacted canines (cusp and root tips) in x, y, z planes were in sector 3 except roots in x axis that were found in y axis. Luis Ernesto et al in their study found, (86.7%) impacted canines in sector 0,1,2 and 3 and 6

% in Sector 4 and 5.²⁰ Crescini A et al reported that the mesial placement of the impacted canines requires at least 6 more weeks of orthodontics treatment.²²

Malik et al also confirmed the credibility of sector class identification by reporting the presence of palatal maxillary impactions in Sector 3 and 4 compared to normally erupting canines.²³ Arriola G et al suggested that treatment duration and complexity of treatment is influenced by not only gender but also position of impacted canine in the bone. According to their study, 2.05 more months are needed for treatment in females.²⁰

In our study the mean canine angle with midline was $34.6^\circ \pm 14.7$. According to Crescini A et al the opening of every 5 degree of α - angle required approximately 1 more week for orthodontic traction.²²

Ericson and Kuroi analysis and Stewart's measurements were not significantly related. This difference could be due to the fact that, former one is used to assess the treatment difficulty and the latter is used to predict the treatment duration.¹⁴ Previous studies have reported some specific features of canine impactions that are directly associated with duration of orthodontic traction that include α angle, d- distance, and impaction sector.^{20,22,24}

Moderate and significant association was found between KPG index and Ericson and Kuroi analysis and Stewart's measurements in our study. These results are not in accordance with another study where a strong association was found with only Ericson and Kuroi analysis.¹⁴ Similarly, Dina M et al reported insignificant difference between KPG index and Counihan et al guidelines.¹⁹ The reason for the weak correlation measurements with Stewarts could be due to the fact, that canine tip position is one of the six factors considered by KPG index. Therefore, the contribution of the index can be masked by rest of the five. Also, the labiolingual cusp and root position was not assessed in 2D method.¹⁴ The significant association in our study can be related to the anatomical factors, as mesial position of the canine leads to increased angulation of the canine. This impacts the KPG index scoring when rating the apex of the root in x and y planes.¹⁴ Similarly, Kim et al found an association between panoramic radiograph sector location and labio-palatal position of impacted canines on CBCT. They reported labial and palatal impacted tooth root apices to be closer to

lateral incisor and premolar roots respectively.²⁵

The reliability of the 3D radiographic images is more as compared to the 2D radiographic images. The measurement from 3D methods is more accurate and so are the indexes derived from them as it determines the treatment peculiarity.^{9,14} There can be overestimation of the angles and the linear measurement taken. As in the anterior maxilla small inter-incisal angle or inter-maxillary discrepancy teeth can become either invisible or out of focus due to narrowing of focal trough.²⁶ This could explain why some measures in 2D indexes were found to be related to treatment duration or difficulty degree only in some studies, while they were considered non-influential by some others. This study compared 2D and 3D indexes to determine the complexity and treatment duration of the impacted canines. As, the accuracy of 2D radiographs, more reliable results could be achieved with comparisons with other 3D methods. Moreover, the complexity of the canine impaction cannot be based only on few variables. In future, further studies can be conducted considering age, gender, type of malocclusion, complexity, oral hygiene maintenance, etc to clinically validate the KPG index. Furthermore, we can conduct a study to compare the sensitivity and specificity of various CBCT machines in determining in accurate localization and root resorption of the impacted canine.

Conclusion

KPG index (3D) measurements, compared to the 2D indexes (Ericson and Kuroi and Stewarts analysis), showed a significant difference. There was a moderate correlation between the 3D KPG index with 2D indexes. Hence, 3D KPG index can be used in place of 2D indices to effectively locate the position of and determine the difficulty level of orthodontic treatment of the impacted canines.

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