

VALIDATION OF KPG INDEX “CLASSIFICATION METHOD TO PREDICT ORTHODONTIC TREATMENT DIFFICULTY LEVEL OF IMPACTED CANINES”

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ABSTRACT

Objective: To determine the position of impacted canine in 3 dimensions and estimate the difficulty of treatment using 3D “KPG index”, a new classification method.

Study Design: Cross sectional analytical study.

Place and Duration of Study: Orthodontic Department, Rehman College of Dentistry, Peshawar, from Aug to Oct 2020.

Methodology: 3D cone beam computed tomography (CBCT) scans of 43 subjects with 47 impacted canines were obtained. Using KPG index, 6 measurements were taken for each impacted tooth in three planes. The scores were later summed up. Based on the cumulative scores, each impaction was classified into the difficulty categories of Easy (0–7), Moderate (8–14), Difficult (15–19), and Extremely Difficult (20+). Comparison of Gender and position of impacted canine with the KPG treatment difficulty index was also performed.

Results: Impacted canines were found to be on the left and palatal side with a female predilection. Canines scored with KPG index were mostly in the moderate category. Highest percentage of the impacted canines were in Sector II, followed by sector III and IV. Comparing KPG treatment difficulty index of impacted maxillary canines found on the right and left sides ($p=0.087$), buccal or palatal ($p=0.545$), males and females ($p=0.279$), in-statistically significant difference was found.

Conclusion: 3D imaging has allowed us to precisely locate the impacted canine in 3 sagittal, coronal and axial planes. Hence, KPG index dictated our anticipated difficulty of treatment.

Keywords: Canine impaction, KPG index, 3D cone beam computed tomography (CBCT).

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INTRODUCTION

Canines are considered as the cornerstones of the mouth and are important both for esthetics and function¹. Impaction of canines has been reported to be second most frequent after third molars^{1,2}. (General prevalence of canine impaction is 1-3%^{1,3}. Recent study in Pakistan reported 5% incidence of canine impaction in Orthodontic population¹. About two third of the maxillary canines are reported to be on the palatal side^{4,5}.

Etiology of canine impaction is multifactorial^{3,6}, including genetics, systemic factors (endocrine disorders, febrile illness, irradiation) local obstruction, local pathology, missing/peg shaped laterals, lack of guidance from the laterals and complicated path of eruption etc^{1,4,5}.

Management of impacted canines is challenging for the orthodontist from both diagnostic and therapeutic point of view⁶. Traditionally, for the diagnosis and management orthodontist, mostly relied on clinical examination and radiographs^{2,4}.

Conventionally, 2D radiographic assessment methods such as orthopantomogram (OPG), cephalometric radiography, and intraoral occlusal or periapical X-

rays are being used for the diagnosis and evaluation of impacted canines^{1,7,8}. The diagnostic accuracy and validity of 2D methods can be underestimated. This can be related to limitations such as distortion of images, inability to assess sectional details in 3 dimensions, reduction of the original volume onto radiographic films due to patient positioning and superimpositions⁹.

Recently, cone beam computed tomography (CBCT) has been introduced with comparatively less radiation exposure and 3-Dimensional imaging capability for all the dental structures³. Today CBCT is preferred over 2D radiological methods due to its reliability and accuracy⁸. Nowadays, its clinical application has widened and is currently being used for maxillo-facial, dental implantology and orthodontic purposes. The advantages of CBCT over medical CT are the isotropic voxel resolution, rapid scan time, limited radiation exposure, various field of view (FOV) and cost effectiveness³.

Various 2D classification systems have been formulated in past including Stewart, Ericson/Kurol, Lindauer and Chapokas⁹. These methods do not consider the buccolingual position of teeth and also need another set of radiographs for precise location of canine⁴. In 2009, KPG index was introduced. It is one of the first index that helps to understand the spatial relationship of the impacted tooth in 3D space¹⁰. This index was

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introduced to standardize diagnosis and predict treatment difficulty helps to classify canine impactions in X, Y & Z, planes and determine/estimate the difficulty of treatment¹⁰.

To best of our knowledge no study has been reported in Pakistan to determine the position and difficulty in management of impacted canine using 3D KPG index.

Therefore, the objective of this study was to use 3D KPG difficulty index to determine the position and to estimate the level of treatment difficulty of impacted canine. Comparisons of gender and position of the impacted canines were also performed with the KPG index. This will help the orthodontist to provide definite treatment plan to the patient both in terms of complexity and time.

METHODOLOGY

The cross sectional analytical study was initiated after the ethics approval from the Research Committee of the institute (ECF No. 2020-08-51). Pre-treatment records of the 43 subjects with impacted canines were collected by screening the orthodontic records at Rehman College of Dentistry, from 2017 to 2020 using consecutive sampling technique. Informed consent was taken from the patients about the use of records in research or for academic activity.

Sample size was calculated using G power* (effect size=0.55, error=0.05, power=0.95).

Inclusion criteria was all unilateral and bilateral maxillary and mandibular canine impactions. Patients with craniofacial anomalies, cleft lip and palate, syndromes, traumatic injuries of jaws/teeth, previous surgeries were excluded from the study.

The sample was collected for all the patients who were referred by the orthodontist to have CBCT for diagnostic evaluation of exact position and location of impacted canines for both maxillary and mandibular regions. The sample included in 47 impacted canines from 32 patients. The images were taken with CBCT apparatus (CS 9000) at 60-90 kV, scanning time of 4-16 seconds, reconstruction time 2 minutes, slice thickness of 0.15 mm, FOV (50-37mm) and voxel (size 76 × 76 × 76 μm). Later overall image was assessed using CS 3600 3D imaging software. The impacted canine was appropriately manipulated in the X, Y, and Z planes of space, and the software’s measurement tool provided the millimetric data necessary to classify the position of canine using KPG Index. See fig-1 the index scored the canine impactions based on the distance from ideal position in three planes of space (sagittal, coronal and axial). Scoring was done for both the cusp tips and root tips. 6 scores were taken per tooth ranging from 0-

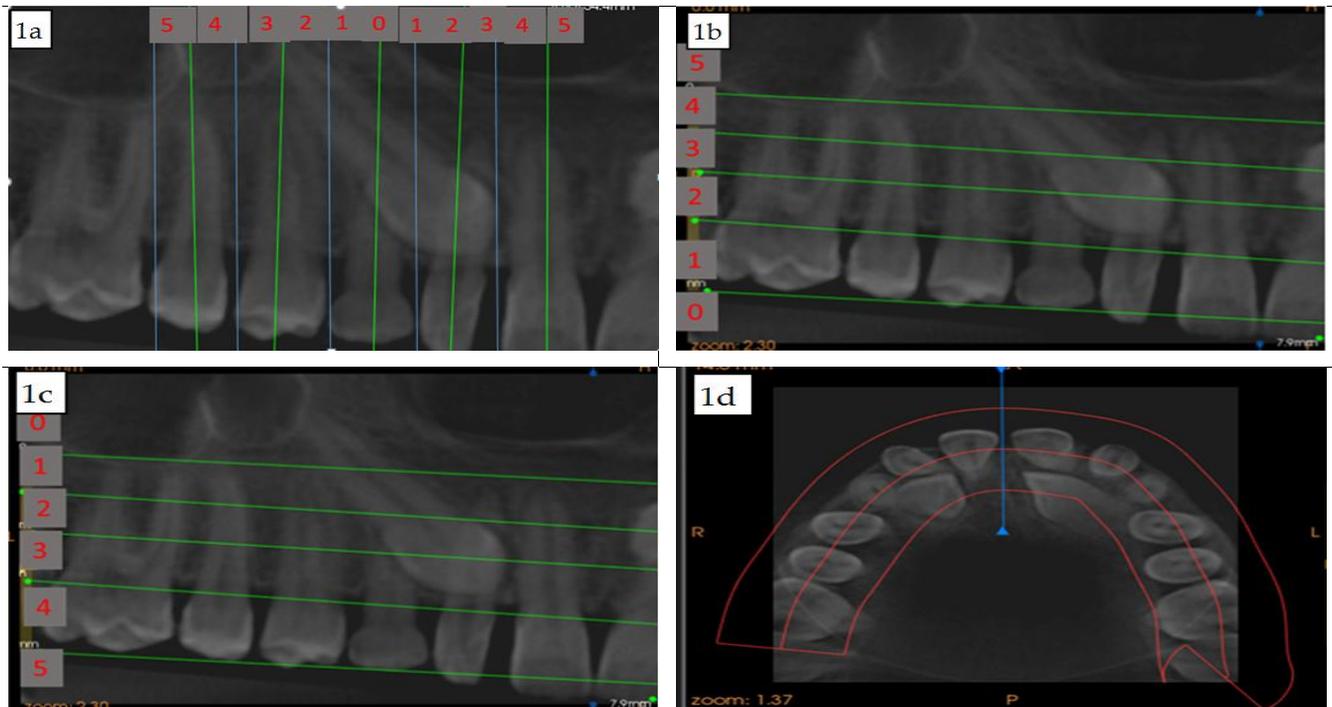


Figure-1: (A) Showing mesiodistal position (X) for both cusp and root tips. In this example CX=3, RX=2 , (B) showing vertical position (Y) cusp tip. In this example CY=3, (C) showing vertical (Y) position of root TIP. In this example RY=0, (D) showing occlusal reference arch and axial view (Z) for both cusp and root TIP. Right CZ=3, RZ=3. Therefore, KPG index value IS 11. (3+2+3+0+3+3=11), considered As moderate category.

5. These scores were later summed up. Based on the scores, each impaction was classified into the difficulty categories of Easy (0-7), Moderate (8-14), Difficult (15-19), and Extremely Difficult (20+)^{10,11}.

Statistical analysis was done using IBM SPSS-20 (Chicago, III). Means and standard deviations were calculated for the descriptive data. The frequency and percentage was calculated for the qualitative data. Comparisons between gender, right and left side, buccal and palatal position of impacted canines with KPG difficulty index were performed using chi-square test. *p*-value <0.05 was considered significant.

Fig-1(a); showing Mesiodistal position (x) for both cusp and root tips. In this example Cx=3, Rx=2, fig-1(b) showing vertical position (y) cusp tip. In this example Cy=3, fig-1(c); showing vertical (y) position of root tip. In this example Ry=0, fig-1d; Showing occlusal reference arch and axial view (z) for both cusp and root tip. Right Cz=3, Rz=3. Therefore, KPG index value is 11. (3+2+3+0+3+3=11), considered as moderate category.

RESULTS

This study sample included (34; 72.3% female, 13; 27.7% male); mean age, 16.02 ± 4.017 years. Mean age of the sample was 16.02 ± 4.017 years. Most of the canines were on the palatal side (68.1%) as compared to buccal side (31.9%). Also, most of the impacted canines were on the left side (51.1%) as compared to right side (48.9%).

In this study CBCT scans of 47 impacted canines were scored for 3D KPG index and based on their position in X, Y and Z planes they were scored and later were segregated from 1-4 difficulty categories. Mean value of the Cumulative score of the KPG index was 14.066 ± 3.205 with a range of 12. Most of impacted canines (55.3%) were scored in moderate category, followed by difficult (34%), extremely difficult (8.5%), and easy category (2.1%).

Gender comparisons with KPG index are given in table-I Most of the impacted canines were in moderate category in females (17 vs 9 males) followed by difficult category (14 vs 2 males). However, the difference

was insignificant (*p*=0.279).

Comparison between the KPG index treatment difficulty with the impacted canines found on the right and left side are shown in table-I. Most of the Impacted canines were on the right side and moderate category. However, the difference was insignificant (*p*=0.545).

Comparison between KPG index treatment diffi-

Table-I: Chi-square test comparing gender and site (buccal / palatal; right and left) with KPG treatment difficulty index.

KPG index Categories	Right or Left		<i>p</i> -value
	Right (n=23)	Left (n=24)	
0-9 (Easy)	1 (4.3%)	-	0.545
10-14 (Moderate)	14 (60.8%)	12 (50%)	
15-19 (Difficult)	6 (26.0%)	10 (41.6%)	
>20 (Extremely Difficult)	2 (8.6%)	2 (8.3%)	
	Buccal or Palatal		
	Buccal (n=15)	Palatal (n=32)	
0-9 (Easy)	1 (6.6%)	-	0.087
10-14 (Moderate)	11 (73.3%)	15 (46.8%)	
15-19 (Difficult)	3 (20%)	13 (40.6%)	
>20 (Extremely Difficult)	-	4 (12.5%)	
	Gender		
	Female	Male	
0-9 (Easy)	1 (2.1%)	-	0.279
10-14 (Moderate)	17 (36.1%)	9 (19.1%)	
15-19 (Difficult)	14 (29.7%)	2 (4.2%)	
>20 (Extremely Difficult)	2 (4.2%)	2 (4.2%)	

p≤0.05*

culty with the impacted canines found on buccal and palatal side (table-I). Mostly impacted canines were on the palatal side and moderate category. Although the difference was insignificant (*p*=0.87).

When sectors (0-5) in three planes were assessed using KPG index. Mostly the impacted canines (crown and root tip) were in sector 3, except root tip in x-axis was in sector 4. None of the impacted canine was found in sector 0 except in root tip in y axis. In x-axis 23.8% canines crowns were in sector 3 and 34% roots were in sector 4, In y-axis 29.18% were in sector 3, In

Table-II: Canine impaction sectors in 3 planes of space (X, Y & Z).

Sectors	Canine Crown and Tip in X, Y and Z Planes, n (%).					
	Canine X-axis Crown	Canine X-axis Root	Canine Y-axis Crown	Canine Y-axis Root	Canine Z-axis Crown	Canine Z-axis Root
1	14 (29.8%)	1 (2.1%)	5 (10.6%)	0	1 (2.1%)	8 (17.0%)
2	8 (17.0%)	11 (23.4%)	15 (31.9%)	0	6 (12.8%)	15 (31.9%)
3	11 (23.8%)	14 (29.8%)	14 (29.8%)	0	18 (38.8%)	16 (34.0%)
4	6 (12.8%)	16 (34.0%)	9 (19.1%)	0	15 (31.9%)	7 (14.9%)
5	8 (17.0%)	5 (10.6%)	4 (8.5%)	0	7 (14.9%)	1 (2.1%)

z-axis crowns and roots were mostly in sector 3, 38.8% and 34 respectively (table-II). Most of the impacted canines were found to be in sector 2 (44.6%), 3 (55.3%) and 4 (39.9%) (fig-2).

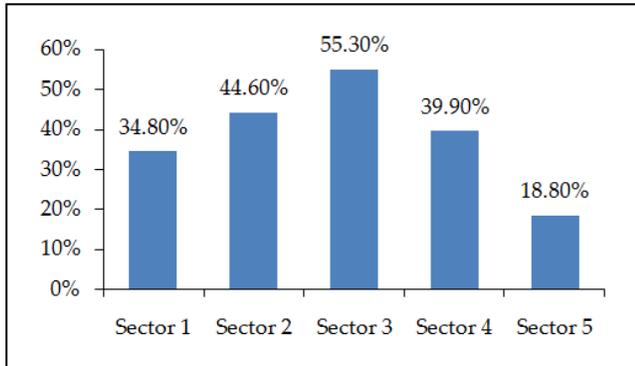


Figure-2: Sector distribution of impacted canines.

DISCUSSION

In dentistry, various classification systems are used to determine the difficulty or the status of the patient's dentition^{10,12}. One of the first classification systems based on ideal position of molar relationship was proposed by Angle^{13,14}. In orthodontics, to predict difficulty or duration of treatment various classification methods are being used based on 2D radiographs. These classification indices include Ericson and Kuroi, Stewart's, and Chapokas analysis^{2,4,10}. Recently, after the advent of CBCT based on 3D radiography^{15,16}, KPG index is recently being used to assess the treatment difficulty and duration. According to Dalessandri *et al*, although KPG system is still a work in progress they proposed their first work in 2009 using 3D coordinates. This system has helped to categorize impacted canines in minimal amount of time to estimate the difficulty of management¹². Therefore this study was aimed to determine the treatment difficulty of impacted canines using KPG index.

Most of the impacted canines in our study were on the palatal side with a female predilection. This is in line with the literature, across the globe and also Pakistan^{1,3,4,16}. The higher frequency of canine impaction in females can be related to their small cranium that might lead to diminution of jaws and facial skeleton¹⁷. This trend can also be related to females being more concerned about their appearance, therefore are more willing to get their orthodontic treatment done¹⁷.

In our study most of the canines were in moderate category (55.3%). This is in agreement with Daniel *et al*, who also reported that, (53.57%) of impacted canines in their study to be in moderate category. In their study, 4 categories of difficulty were related to the ave-

rage treatment duration. Moderate category took almost of 340.9 days or 11.36 month time and an extremely difficult category took 397 days or 13.23 months¹³. Similar, results of Beshlawy *et al*, also reported 33.3% of impacted canines in moderate category¹⁸.

The mean summative score of the sectors (x, y, z) planes in our study was 14. This score also confirms moderate category (7-14) of impacted canines. Theoretically, based on 0-5 score of the KPG index, total score should be 30. However, in Y axis because of the origin of the canine high in the maxilla root tip is rated as 0. To rate the canine root tip as 5, it has to cross the crown of the adjacent teeth^{11,19}. Literature, suggests selection of the anatomical location is mostly at the discretion of the orthodontist and choosing a specific sector may influence the sum and so, the potential management and outcome. CBCT allows the accurate visualization of the canine's root tips in the axial planes. Beshlawy *et al*, suggested the use of a properly selected sagittal cut instead of axial cut is more accurate in determining the position of impacted canine¹⁸.

Most of the crown and root tips in three planes of space were in sector 3, except the root tip in x-axis that was in sector 4. Based on cumulative score, highest percentage of the impacted canines were in sector 3 followed by sector 2 and 4. Studies of Lindauer's and Warford *et al* correspond to each other's and our findings. Impacted canines in their studies were mostly in Sector II, III & IV¹¹. Cuc *et al* reported palatal impacted canines in study were mostly found in in sector 4 and 5 as compared to the buccal canine impactions in sector 1.16 Literature suggests, determining the position of root tip of canine is very crucial as, proximity of the root to the adjacent structures can vary the real difficulty of impacted canine management^{6,20,21}.

When KPG index treatment difficulty was compared with gender, although most of the impacted canines were found in females, the difference was insignificant. This is in accordance with the results of Beshlawy *et al*, who also reported insignificant difference. This shows that position of the impacted canine has minimal effect on patients, gender and the related management¹⁸. However, this is in contrast to the findings of Al Hammadi *et al*, who conducted a study on Saudi population on panoramic radiographs and reported difficulty index to be higher in males. The difference could be attributed to variation in selection of study population and methodology²².

Comparison of KPG treatment difficulty with right and left sides, revealed insignificant difference. Similarly, buccal and palatal position of impacted can-

ine compared to KPG index, showed insignificant difference. The results are in accordance with previous studies, showing the side and position of the impacted tooth has no effect on the treatment difficulty of the impacted canines¹⁸.

It was a retrospective study. In future prospective clinical trials can be designed to compare the 2D and 3D methods to determine the difficulty level of the impacted canine. Also, prospective validation studies can be conducted to check the reliability of KPG index in our settings. Moreover, future research can be conducted to relate the difficulty of impacted canine with the type of management and approximate treatment duration.

CONCLUSION

3D imaging has allowed us to precisely locate the impacted canine in sagittal, coronal and axial plane the new 3D KPG index classification system incorporates 3-dimensional information in CBCT imaging. KPG index predicts difficulty of orthodontic treatment. Position, site and gender had no effect on treatment difficulty index.

CONFLICT OF INTEREST

This study has no conflict of interest to be declared by any author.

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