

Position of Unilateral / Bilateral Permanent Canine Impaction on the Prognosis of Treatment with KPG Index: 3D Cone Beam Computed Tomography Analysis

Nina Agustin Chrystinasari¹, Ida Bagus Narmada^{1*}, Ari Triwardhani¹

1. Orthodontic Departement, of Faculty of Dental Medicine, Universitas Airlangga, Surabaya, Indonesia.

Abstract

This study investigates the difficulty level of the impacted maxillary canines based on the KPG index of orthodontic patients. Setting and Design: This was a descriptive-analytical study.

This study explained the agreement between the assessors towards the mesiodistal position of the maxillary permanent impacted canines on the treatment prognosis with the KPG index through CBCT analysis. The research sample determined CBCT images of treatment patients at the Orthodontic Specialist Polyclinic in Dental Hospital of Airlangga University who met certain criteria for the last three years since this study began and secondary data taken from patients. CBCT images from Pramita Laboratory that meet the inclusion criteria. Statistical analysis Data that had been obtained then was processed with statistical software, SPSS version 21. Statistical analysis was performed using Cohen's Kappa measuring test to determine coefficient and significance values of Cohen's Kappa Measuring Test.

The coefficient value of Cohen's Kappa is 0.689. There is a difference in assessment between assessors 1 and 2 for the same case although this difference is not significant. The estimated significant value is 0.000, which indicates that the hypothesis is accepted with preconditions (sig value <0.01). Thus, it can be concluded that assessor 1 and assessor 2 have a significant similarity in the assessment of unilateral/bilateral permanent maxillary canine impacted cases.

The KPG index can be used to determine the position of canine, the severity of treatment in impacted canines, and to evaluate precisely the distance of canine from the ideal position.

Clinical article (J Int Dent Med Res 2021; 14(4): 1523-1530)

Keywords: Canine Impaction, CBCT, KPG Index.

Received date: 24 August 2021

Accept date: 10 October 2021

Introduction

The teeth in the oral cavity will grow according to the time sequence of each tooth eruption, starting from the growth phase of the primary teeth to turning into permanent teeth. In general, permanent teeth erupt in an occlusal direction, completely replacing primary teeth.¹ However, sometimes the teeth fail to erupt and become stuck in the alveolar bone. Impacted teeth are teeth that have not fully or partially erupted and are placed on other teeth, bone or soft tissue so that further eruptions are not possible, explained according to their anatomical position. The most commonly impacted teeth are

the third molars, followed by the maxillary canines and the mandibular second premolar teeth.² Canines are the second teeth after the third molars that have a high frequency of impact, but other maxillary anterior teeth, such as the first and second maxillary incisors, can also have difficulty growing due to the wrong position of the jaw. Eruption disorders of permanent maxillary canines occurred because most of them experienced the longest development period, the most extensive development, and the most difficult eruption process compared to other teeth in the oral cavity.³

The maxillary canines are essential for aesthetics and functionality. Impacted canines may exhibit several complications such as root displacement and resorption of adjacent teeth, degenerative cysts, canine ankylosis, arch shortening or some combination of these factors.⁴ Affected canines are complex in terms of cause, location, response to preventive maintenance, and prediction of success. This

*Corresponding author:

Ida Bagus Narmada
Orthodontic Department, Faculty of Dental Medicine,
Universitas Airlangga, Kampus A, Jl Prof Dr Moestopo, No.
47, Surabaya 60132, East Java, Indonesia.
E-mail: ida-b-n@fkg.unair.ac.id

poses a dilemma for many orthodontics in determining whether an impacted canine is present and how it is treated. In some cases, if orthodontic treatment is not started at a young age, it can lead to ankylosis of the canines and roots of the incisors. An Orthodontist must be able to detect the initial impact of the canines and be able to provide several effective treatment techniques. For this reason, it is necessary to know the location of the impacted canine accurately in order to obtain an optimal treatment technique. Early detection of affected maxillary canines reduces treatment time, complications, and treatment costs. The management of impacted teeth usually requires intervention from orthodontists and oral surgeon and the interventions can be very different between the two.^{3,4}

The management of impacted teeth requires a precise and accurate diagnosis including the location of the impacted teeth, the surrounding anatomical structure, the slope of the long axis of the impacted teeth and adjacent teeth, so that after receiving the correct diagnosis, a treatment plan can be carried out. The position of the affected canine and its treatments are the two main factors affecting the total treatment time and the final position of the canine in the oral cavity. Radiography examination is very important to establish the correct diagnosis and optimal management without many complications because these images will provide accurate information about the position of the teeth, the number and shape of the roots, and the relationship of the teeth and the surrounding anatomical structures. Radiography examination is always done if at the time of clinical examination an impacted tooth is found. Two-dimensional radiographs for preoperative diagnosis that are often used are local and panoramic radiographs. Two-dimensional radiographs including conventional radiographs (local and panoramic), cephalometry, and videos are part of the medical records of orthodontic patients that have been done over the years. Radiography is needed to determine the diagnosis, treatment plan, treatment procedures, prognosis, follow-up, and education for patients. Meanwhile, distortion is often found on 2D radiographs.⁴⁻⁶

With the latest technology such as Cone Beam Computed Tomography (CBCT), the affected canines can be precisely positioned in

three dimensions. The CBCT machine is a newer technology that was originally developed for angiography in 1982 and was later used for maxillofacial imaging.⁶ CBCT using a cone-shaped X-ray produces 3D reconstructive images of the teeth and jaw. With CBCT, it is possible to obtain the position of the impacted canine, view the amount of bone covering it and evaluate the condition of the surrounding anatomical structure. Furthermore, CBCT is able to overcome the limitations of conventional 2D radiographic images.⁴

Orthodontic treatment at the orthodontic Specialist polyclinic in Dental Hospital of Airlangga University has used CBCT as a supporting examination in determining the prognosis of orthodontic treatment, including the position of the impacted canines. Early prediction of the affected canine is the key to successful treatment, and the failure of early diagnosis will be a problem in its treatment. Furthermore, the classification used is the KPG index as the first 3D classification system for impacted maxillary canines. This index determines the position or degree of severity of impacted canines which are divided into 3 areas, which are X, Y, and Z axes and predicts the level of difficulty of treatment.⁷ Furthermore, This study aims to investigate the level of difficulty in the position of impacted maxillary canines based on the KPG index of orthodontic patients treated at Airlangga University Dental Hospital.

Materials and methods

This research had been reviewed and approved by the Health Research Ethics Commission (KEPK), Faculty of Dental Medicine, Airlangga University with the ethical number 49d/HRECC.FODM/XI/2020. The design of this study was a descriptive-analytical study to explain the agreement between the assessor towards the mesiodistal position of maxillary permanent impact canines on the treatment prognosis with the KPG index through CBCT analysis.

The population in this study were all CBCT image data of treatment patients at the Orthodontic Specialist Polyclinic in Dental Hospital of Airlangga University Dental Hospital. The research sample was determined through the total sampling method by considering the novelty and availability of research data. The

research sample determined CBCT images of treatment patients at the Orthodontic Specialist Polyclinic in Dental Hospital of Airlangga University who met certain criteria for the last 3 (three) years since this study began, 2018, 2019 and 2020 as well as secondary data are taken from patients. CBCT image from Radiology Laboratory. The method used is the total sample method, involving all patients from Orthodontic Specialist Polyclinic at Dental Hospital of Airlangga University that meets the 2018 - 2020 period criteria.

The inclusion criteria of the sample in this study were all patients who came to the Orthodontic Specialist Polyclinic at Dental Hospital of Airlangga University in 2018-2020, patients who had permanent maxillary canine impacted teeth, had not and were undergoing orthodontic treatment but had never had canine impact surgery, teeth. canine in perfect anatomical condition without any abnormalities, and the patient is more than 13 years old. The exclusion criteria of this study sample were patients without impacted maxillary permanent canines, patients who had undergone canine surgery, patients who had anomalies numbers of teeth, and patients with jaw anomalies. Furthermore, the CBCT image will be assessed using the KPG index with three different dimensions (zone x, y, z) which are used to determine the score at the cusp tip and the root tip based on the deviation from the normal position and each is numbered on a scale of 0-5.⁷ Eighteen CBCT scand of 18 patients (14 females and 4 males) with on age range varying from 13 to 26 years were included in the current study with a total number of 26 impacted maxillary canines.

Kau *et al* in 2009 showed the method to determine the score at the cusp tip and the root tip based on the deviation from the normal position and it divides into three zone.⁷

- X-Zone: the zone for the horizontal dimension measuring the mesiodistal position of the cusp tip and root tip of the canine against adjacent teeth, using panoramic views from the CBCT, each numbered on a scale of 0-5 (Fig. 1 and Fig. 2).

- Y-zone: the zone for the vertical dimension measuring the position score of the height of the cusp tip and tip of the canine root against adjacent teeth, using the CBCT panoramic view, and each numbered on a scale

of 0-5, divided as corona, cervical one-third from the root, middle third from root, apical third from root, and superior of apical (supraapical) (Fig. 3 and Fig. 4).

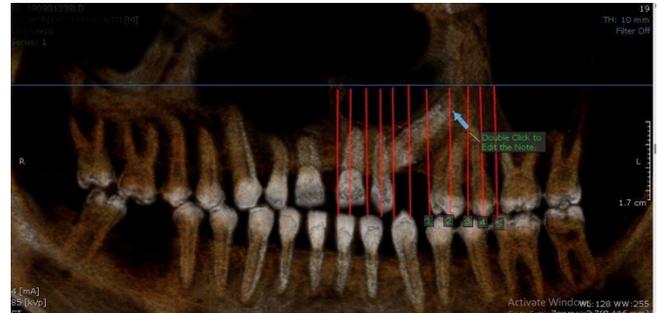


Figure 1. Determining the X-zone of the apical on the maxillary canine impaction.

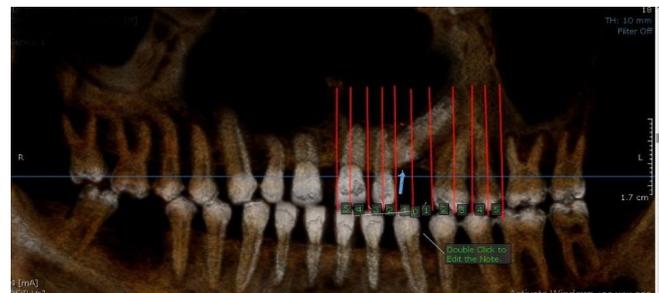


Figure 2. Determining the X-zone of the coronal on the maxillary canine impaction.

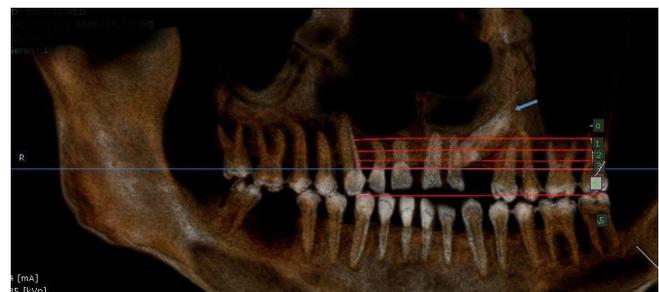


Figure 3. Determining the Y-zone of the apical on the maxillary canine impaction.



Figure 4. Determining the Y-zone of the coronal on the maxillary canine impaction.

- Z-zone: zone for axial views on CBCT using distances measured perpendicular to within 2 mm from the tip of the cusp/root tip to the occlusal arch. The 0-5 scale is based on the distance from the cusp tip and root tip of the impacted tooth to the occlusal arch and is each numbered on a scale of 0-5 (Fig. 5 and Fig. 6).
 Maxillary canine severity:
 - Easy: Total score (X, Y, Z) 0-9
 - Moderate: Total scores (X, Y, Z) 10-14
 - Difficult: Total scores (X, Y, Z) 15-19
 - Extremely difficult: Total scores (X, Y, Z) > 20

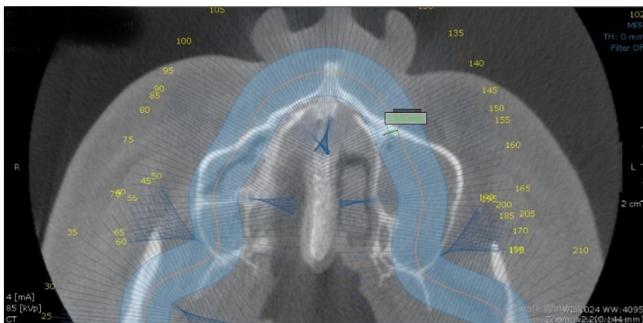


Figure 5. Determining the Z-zone of the apical on the maxillary canine impaction.

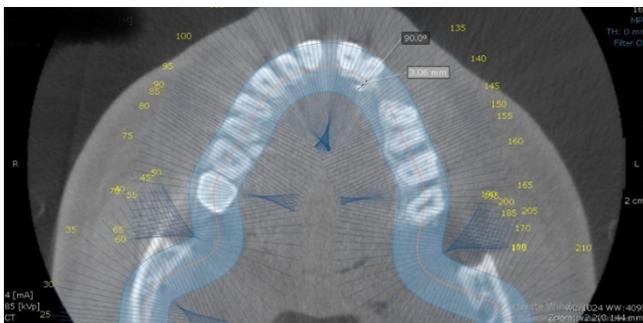


Figure 6. Determining the Z-zone of the coronal on the maxillary canine impaction.

The data were obtained were processed with statistical software, Statistical Package for Social Science version 21 (Illinois, US). The data were measured using the Cohen's Kappa statistical test to determine the coefficient and significance values of the Cohen's Kappa Measuring Test. The Cohen's kappa coefficient (κ) is a statistic used to measure inter-assessor reliability for qualitative (category) items. This coefficient is a more robust measure than a simple percent agreement calculation, because κ takes into account the likelihood of an agreement occurring by chance. Inter-rater reliability refers to the consistency of ratings given by different ratings for the same subject. It quantified the

extent to which the assessor agreed to the relative ratings given to the subjects and served as a measure of the quality and accuracy of the assessment process.⁸

Results

This study was conducted on 26 impacted maxillary canines found in 26 patients; 12 on the left (46%) and 14 on the right (54%) side; 10 patients (56% of cases) had unilateral impacted maxillary canine while 16 impactions were found bilaterally in 8 patients (44%) bilateral.

Based on table 1, we know that the mean of the score result on patient with maxillary canine impaction according to the KPG index is 15.19. Meanwhile, the maximum score of the prognosis of patient using KPG index is 21 and the minimum score is 5. According to the table 2, the proportion of patients based on gender shows that there are more female patients, namely 78% compared to 22% of male patients. This shows that women are more susceptible to cases of impacted canines.

Mean	Median	Mode	Std. Deviation	Variance	Range	Minimum	Maximum
15.19	15.5	15	3.92	15.36	16	5	21

Table 1. Descriptive of Score Result according to The KPG Index on Patient with Maxillary Permanent Canine Impaction.

Variable	N (%)
Gender	
Male	4 (22,2%)
Female	14 (77,8%)
Total	18 (100%)
Type of Canine Impacted	
Unilateral	10 (56%)
Bilateral	8 (44%)
Total	18 (100%)
Position of Canine Impacted	
Left Impaction	12 (46%)
Right Impaction	14 (54%)
Total	26 (100%)

Table 2. Frequency Distribution of Patient with Maxillary Permanent Canine Impaction.

Meanwhile, when viewed from the type of canine affected, the number of unilateral and bilateral cases was actually almost the same, where there were slightly more unilateral cases, namely 56% compared to bilateral cases, namely 44%. The same thing is seen in the affected positions, namely the left and right with the proportions that are not much different, namely 46% and 54%, respectively. So, it can be concluded that the type of impaction and its position do not have a dominant tendency.

Table 3 shows the distribution result of impacted canine cases based on the level of difficulty. Based on the table, it can be seen that the difficulty level is difficult to take the largest number, both assessed by assessor 1 and assessor 2 as many as 14 cases or equivalent to 54%. whereas the cases with the easiest difficulty level were in the position of the least impacted cases, namely 2 cases or the equivalent of 8%. Meanwhile, there were differences in the assessments carried out by the two assessors at medium and very difficult levels of difficulty, the difference between the two assessors at the stated difficulty level was only a point difference.

Variable	N (%)	
Assessment by Difficulties		
Easy	2 (8%)	
Moderate	6 (23%)	
Difficult	14 (54%)	
Extremely Difficult	4 (15%)	
Total	26 (100%)	
Assessment by Difficulties and Gender		
Gender	Female	Male
KPG Index	Easy	0 (0%)
	Moderate	4 (15%)
	Difficult	1 (4%)
	Extra Difficult	0 (0%)
Total	21 (81%)	5 (19%)
Assessment by Difficulties and Impaction Position		
Impaction Position	Left	Right
KPG Index	Easy	0 (0%)
	Moderate	5 (19%)
	Difficult	6 (23%)
	Extra Difficult	3 (13%)
Total	12	14
Assessment by Difficulties and Kind of Impaction		
Kind of Impaction	Unilateral	Bilateral
KPG Index	Easy	1 (4%)
	Moderate	3 (12%)
	Difficult	9 (34%)
	Extra Difficult	3 (12%)
Total	10	16

Table 3. Distribution of Assessment by Difficulties, Difficulties and Gender, Difficulties and Impaction Position.

Meanwhile, the majority of female impacted patients experienced cases with a difficult level of difficulty, namely 13 patients, equivalent to 50% of the total cases. while the majority of male patients experienced impaction cases with moderate difficulty, namely 4 cases or the equivalent of 15% of the total cases. It can be said that women impaction sufferers have very few cases of impaction with the easiest and medium difficulty level, the number of the easiest cases and the moderate number of cases is 4 cases or only equivalent to 16% of the total case. Meanwhile, male impacted patients do not experience difficult and very difficult cases of impaction.

When viewed from the point of view of the position of impacted canines, the left impacted position is more than the right impacted position on the difficult difficulty level, namely 8 versus 6 or the equivalent of 31% compared to 23% of the total impacted which is affected. Meanwhile, the position affected by the right was more than the position affected by the left at a moderate level of difficulty, namely 5 cases versus 1 case or the equivalent of 19% versus 4% of the total cases. This is similar to the impaction case with a very difficult level of difficulty where the right impacted position is more than the left impacted position with a ratio of 3 cases to one case or the equivalent of 12% compared to 4% of the total cases. At the easiest difficulty level, there are no cases of impaction with the right position or in other words 0 cases.

Based on table 4 it can be seen that the coefficient value of Cohen's Kappa is 0.689. This value falls into the category defined by Landis and Koch (1977), which falls into the category of substantial agreement.⁹ Substantial agreement could mean that the first and second assessors had substantially the same assessment of unilateral / bilateral impacted permanent maxillary canines.

Coefficient Value	p-value
0.698	0.000*

Table 4. Cohen's Kappa Analysis Test Results.

Discussion

An impacted tooth is a tooth that fails to erupt into the arch within the expected timeframe. An impacted tooth results from a lack of space, a

dense layer of bone or thick soft tissue, chronic infection, and developmental abnormalities of the tooth. Wrong way of eruption of permanent teeth, most likely caused by failure of primary tooth resorption resulting in persistence and can lead to failure of eruption of permanent teeth so that the teeth become impacted. Upper canines are the second most frequently impacted teeth after third molars. In general, teeth are impacted due to the length of the dental arch that cannot accommodate the teeth and the length of the dental arch which is smaller than the total mesiodistal length of the tooth. The frequency of canine impaction is 0.8 – 2.8% and is more common in women than in men. Impacted canines are 18 to 20 times more common in the maxilla than in the mandible and 85% are located in the palatal part of the dental arch.^{1,10}

KPG index as a 3D classification system for maxillary canine impaction. The degree of difficulty of the treatment of impacted teeth is based on information from CBCT. The KPG index aims to enable practitioners to estimate the difficulty level of the treatment of impacted canines quickly, without repeated measurements of angles and distances to estimate the patient's treatment plan. This index measures the canine CBCT images with three different dimensions (zones x, y, z) which are used to score the cusp tip and root tips based on their deviation from the normal position and each is numbered on a scale of 0-5. The number of scores obtained will determine the classification of the difficulty level of treatment, namely easy, moderate, difficult, and extremely difficult. This index is the first index to measure the severity of maxillary canine impaction using 3D.⁷ CBCT has been known to cover radiographic deficiencies with 2 dimensions. In addition, the prognosis for the position of the impacted tooth can be accurately assessed and its relationship to the supporting tissues.¹¹

Utilization of radiography using 3-dimensional CBCT in this study can be used as an evaluation material for the impacted canine which will be very useful in determining the accuracy of the position or location of the impacted tooth, besides that it can also determine the adjacent teeth, and anatomical landmarks. The use of CBCT is now the gold standard because it can show 3D images clearly which allows linear reproduction and angular measurements for researchers to avoid errors. It

is necessary to select cases before carrying out orthodontic treatment of impacted maxillary canines because not all impacted canines can be guided by their eruption into a good dental arch, depending on the direction of eruption of the tooth. The direction of eruption of the impacted tooth to the occlusal plane, at an angle of not more than 45 degrees to the median line of the face, located on the distal side of the lateral incisor and no ankylosis has a good prognosis for orthodontic treatment. The results of orthodontic treatment of impacted maxillary canines were also influenced by the patient's motivation and level of adherence to treatment instructions, overall oral health and the patient's age. The optimal age for maxillary canine treatment is adolescence. Treatment of impacted canines requires collaboration between an Oral Surgeon and an Orthodontist. Orthodontists work to select cases, determine prognosis and guide eruption of impacted teeth into a good arch, while oral surgeons perform surgical exposure so that the brackets can be bonded to the teeth. A good surgical exposure technique can facilitate the process of completing orthodontic treatment. The results of orthodontic treatment with good aesthetics and high stability are also influenced by surgical exposure techniques in addition to the orthodontic technique itself.^{4,11,12}

The conventional treatment for an impacted anterior tooth is surgical exposure and orthodontic traction. Management of impacted deep canines is more difficult than other maxillary anterior teeth. This is due to its location which causes the teeth to often collide with hard bone tissue. This situation can stop the rate of tooth eruption, so surgery is needed to remove the obstructing bone. The prognosis for a successful canine eruption depends on several factors including the patient's age, the presence of diastema, the presence of crowding teeth, as well as the vertical and anteroposterior dimensions, whether or not the crown is inverted. If the inclination of the tooth to the median line of the face is more than 45 degrees, it will have a poor prognosis for eruption.¹¹

In 2009, the KPG index, as an innovative 3D classification system for canine impaction, was introduced. This classification is seen from the impaction distance of the canine to the normal position by giving a score on the root tips and cusp tips with a scale range of 0-5 on the x-y-z planes. The sum of the scores of the three

will predict the difficulty level of treatment of impacted canines, which are classified as follows: easy (0 – 9), moderate (10 – 14), difficult (15 – 19), and extremely difficult (above 20).⁷ Researchers used CBCT Sirona Galileos to analyze 26 canine impactions and evaluate them using Galaxis software. The same method has been used in previous studies. The management of CBCT scans can be done first by selecting the axial CBCT section of the impacted canine by looking at the panoramic image with increased thickness to show the relationship between the impacted canine and the adjacent tooth. Root tips and cusp tips against the normal position and are given a score of 0-5. Then the selection of the axial section showing the cusp tips of the impacted canine, the labiolingual position (Z axis) was evaluated and scored from 0 to 5 based on the distance of the impacted tip to the occlusal arch with a distance of 2 mm increments. Researchers measured the z axis by drawing a line perpendicular from the root tips to the long axis of the alveolar bone and scored from 0 – 5 with the KPG index.^{7,10,14}

From the results of this study, 26 maxillary canine impacted CBCT scans were obtained from 18 patients (4 males and 14 females) aged 13 to 36 years. This is in accordance with previous research that has been done by Chuc Thi Thu et al in 2018 which found more female subjects (58%) than male subjects (42%).¹⁵ Previous study also found that the incidence of maxillary canine impaction was higher in women (83.3%) than men (16.7%). It was speculated that this difference was due to differences in growth and development by sex, in addition to the higher need for women for aesthetic orthodontic treatment compared to men. The gender differences are due to the smaller skull and jaw size in women than in men, and proper jaw size is an important factor in promoting the development and eruption of teeth in their proper place.^{14,16} A typical similar result to ours was found by Zarch et al in 2013 where the majority of their patients were females (80%). They explained that this may be due to the variances in the craniofacial growth between males and females or even due to the higher demand of females for aesthetic purpose resulting in more regular orthodontic visits compared to males.¹⁴

In the current study, 56% of maxillary impacted canine cases were unilateral while only 44% were found bilateral. Similarly, Pico et al

2017 found that the frequency of unilateral and bilateral impaction was 60% and 40% respectively.¹⁷ Beshlawy et al 2019 found that the frequency of the unilateral and bilateral impaction was 75% and 25%. Moreover, another previous study showed that the majority of impaction of maxillary canine are unilateral.¹⁶

An almost equal distribution of impacted maxillary canine was found in our result on both sides (12 on the left (40%) and 14 on the right (54%) side). Beshlawy et al reported a higher prevalence of impacted maxillary canines on the right side compared to the left side.¹⁶ Al Zoubi et al at 2017 concluded that these are no scientific evidences to clarify the higher prevalence of maxillary canine impactions and it might be only considered as a general feature of the malformation.¹⁸ On comparing the treatment difficulty and prognosis at impacted maxillary canines found on the right and left side, this may indicate that the side has no effect on the position of the impacted canine and accordingly their treatment duration difficulty.

On comparing the treatment difficulty and prognosis of impacted maxillary canines found in male and females. Al Hammadi et al 2018 studied the treatment difficulty index of maxillary canine impaction in Saudi population on panoramic radiographs found that the canine impaction was twice as common in females than males, the orthodontic treatment difficulty index was significantly higher in males than female.¹⁹

The results show that the CBCT image is very important to show the position of the impacted permanent canine using the KPG index, besides that it can also see the presence of root resorption, the presence of root anomalies in the impacted canine. Previous studies have also linked the canine position to the duration of treatment with the level of difficulty. Based on anatomical factors, the canine angulation tends to move towards the mesial which has an impact on the root apex on the x and y scores when measured with the KPG index. Accurate knowledge is needed to determine the position of the impacted canine which may contribute to the choice of less invasive treatment when removal of the canine is required. The use of a variety of radiographic techniques, including the parallax technique, occlusal vertex radiography, with different contrasts, stethoscopy, pantamography, various radiographic techniques, and panoramic views can be used to visualize local images.

Three-dimensional images using CBCT can be used to cover radiographic deficiencies with two dimensions.²⁰ In addition, the prognosis of the impacted tooth and its relationship to the surrounding anatomic tissue can be well known. The use of CBCT in this study is very helpful in showing the location of teeth accurately, surrounding teeth, and each anatomical part. In addition, CBCT uses spatial relations and shows contrast in the network. The costs, efficiency and benefits of CBCT are numerous to be able to see the important features, location and position of impacted maxillary canines.²¹

The KPG index has demonstrated to be an effective for classification of maxillary impacted canines treatment difficulty in accordance to their position. Beshlawy et al stated that correlation between the impacted canine position with treatment duration and difficulty using KPG or any strategy.¹⁶

Conclusions

3D radiographs can produce clear images for viewing impacted teeth in the arch of the jaw. The KPG index is an index that can provide 3D images on CBCT radiographs. CBCT provides accurate radiographic results, which is important in determining the position of the impacted teeth and determining the degree of severity of treatment for impacted canines based on the KPG index. The KPG index to determine the position of the canine and the severity of treatment in the affected canine using 3 dimensions to be able to evaluate precisely the distance of the canine from the ideal position.

Acknowledgments

Thank you to all the staff of Orthodontic Specialist Polyclinic in Dental Hospital of Airlangga University Dental Hospital and all the subjects of this research who have supported this research.

Declaration of Interest

The authors report no conflict of interest.

References

1. Ardani IGAW, Rahmawati D, Narmada IB, Nugraha AP, Nadia S, Taftazani H. Surface Electromyography Unveil the Relationship between Masticatory Muscle Tone and Malocclusion Class I & II in Javanese Ethnic Patient. *J Int Dent Med Res* 2020; 13(4): 1447-1454
2. Litsas G, A Review of Early Displaced Maxillary Canines: Etiology, Diagnosis and Interceptive Treatment. *The Open Dentistry Journal*. 2011;5(1):39-47. <https://doi.org/10.2174/1874210601105010039>
3. Park JH, Srisurapol T, Tai K. *Impacted Maxillary Canines Diagnosis dan Manajemen*. *Dent Today (CE Test)*. 2012. 31(9): 62, 64-6; quiz 68-9
4. Alqerban A, Jacobs R, van Keirsbilck PJ, 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 Apr;3(2):34-40. doi: 10.4103/2278-0203.132911.
5. Basrani B. *Endodontic Radiology: Second Edition*. New Jersey(USA):Wiley-Blackwell, 2017
6. Pauwels, R., Beinsberger, J., Collaert, B., Theodorakou, C., Rogers, J., Walker, A., et al. Effective does range for dental cone beam computed tomography scanners. *Eur. J. Radiol*. 2012; 81, 267-71
7. Kau CH, Gallerano RL, English YD, et al. A Novel Classification System for Canine Impaction – the KPG Index. *Int J Med Robotics Comput Assist Surg*. 2009. 5(3): 291-6.
8. Cohen J. A Coefficient of Agreement for Nominal Scales. 1960, *Educational and Psychological Measurement*. <https://doi.org/10.1177/001316446002000104>
9. Landis JR, Koch GG. The Measurement of Observer Agreement for Categorical Data. *Biometrics*. 1977. <https://doi.org/10.2307/2529310>
10. Bin Y, Zongyang S, Hendry F, Ling W, Limin L. Etiologie Factors for Buccal and Palatal Maxillary Canine Impaction: A Prespective Base on CBCT Analyzer. *Am J. Orthod Dentofacial Orthop*. 2013. 143(4). 527-34. <https://doi.org/10.1016/j.ajodo.2012.11.021>
11. Iswanto H, Titien SI, Rahardjo R. Penatalaksanaan Impaksi Kaninus Kiri Atas dengan Posisi Horisontal pada Anak. *Maj Kedokt Gigi Klin*. 2015;1(2):92-8. <https://doi.org/10.22146/mkgk.11961>
12. Razi T, Niknami M, Alavi Ghazani F. Relationship between Hounsfield Unit in CT Scan and Gray Scale in CBCT. *J Dent Res Dent Clin Dent Prospects*. 2014; 8(2): 107 – 10. <https://doi.org/10.5681/joddd.2014.019>
13. Setiawan H. Prihandini. Seleksi Kasus dan Perawatan Ortodontik pada Gigi Kaninus Maksila Impaksi. *Jurnal MKG*. 2011. 18(2): 152-5. <https://doi.org/10.22146/maikedgiind.15410>
14. Zarch SHH, Heravi F, Langaroodi AJ and Pirgazi H. Evaluation of Cone Beam Computed Tomography in Diagnosis and Treatment Plan of Impacted Maxillary Canines. *J Dent Mater Tech*. 2013; 2(3): 92-8
15. Ngo CTT, Fishman LS, Rossouw PE, Wang H, Said O. 2018. Correlation between Panoramic Radiography and Cone Beam Computed Tomography in Assessing Maxillary Impacted Canines. *Angle Orthodontist*. 2018; 88(4): 384-9. <https://doi.org/10.2319/103117-739.1>
16. El Beshlawy DM, Ahmed DF. Radiographic Assesment of Impacted Maxillary Canine Position Using CBCT : A Comparative study of 2 Methods. *EDJ*. 2019; 65(4): 3393-402.
17. Pico CLVR, do Vale FJF, Caramelo FJSFA, Corte-Real A, Pereira SMA, Comparative analysis of impacted upper canines: Panoramic radiograph Vs Cone Beam Computed Tomography: *J Clin Exp Dent*. 2017;9 (10): e1176-82.
18. Al-Zoubi H, Alharbi AA, Ferguson DJ, Zafar MS. Frequency of impacted teeth and categorization of impacted canines: A retrospective radiographic study using orthopantomograms. *Eur J Dent* 2017; 11:117-21.
19. Alhammadi MS, Asri HA, Almashraqi, AA. Incidence, severity and orthodontic treatment difficulty index of impacted canines in Saudi population. *J Clin Exp Dent*. 2018;10(4): e327-34.
20. Guerrero, M. E., Shahbazian, M., ElsienaBekkering, G., Nackaerts, O., Jacobs, R., & Horner, K. The diagnostic efficacy of cone beam CT for impacted teeth and associated features: a systematic review. *Journal of oral rehabilitation*, 2011; 38(3), 208-16.
21. Miresmaeili A, Farhadian N, Mollabashi V, et al. *Web-based evaluation of experts' opinions on impacted maxillary canines forced eruption using CBCT*. *Dental Press J Orthod*. 2015;20(2):90-9.