CBCT Evaluation of the Severity of Maxillary Impacted Canines Using the KPG Index

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The use of CBCTs (cone beam computer tomography) instead of 2D radiographs in impacted tooth cases allows precise localisation of the impacted canine in all three axial directions, accurate evaluation of its relations with its neighbouring structures and spatial estimation required for the placement of the impacted canine on the arch. Together with today's technological advancements, CBCT has improved, as well as its accuracy to localise impacted maxillary canines with the KPG index a system for 3D classification of impacted maxillary canines on CBCT, in report to its ideal position on the arch. The aim of this study was to evaluate the treatment difficulty for impacted maxillary canines by the use of the KPG index, for a study group of patients being diagnosed with impacted maxillary canines. Based on this, the orthodontist can rapidly establish the treatment level of difficulty for the impacted canine.

Keywords: CBCT, maxillary impacted canines, KPG index

Treatment of impacted canines has always been seen as a challenge for an orthodontist, both from a diagnostic point of view, as well as creating a therapeutic plan [1-3]. For a treatment plan to be correct it is absolutely necessary to determine accurately the position of the impacted tooth in a three-dimensional space. 2-D radiographs were used and still are to find the localisation of the respective tooth, to estimate its grade of difficulty and treatment time necessary being based solely on the clinical experience of the orthodontist. In addition, the lateral cephalometric radiographs represent an excellent tool to evaluate the associated orthodontic anomalies, especially in the sagittal and vertical plane (e.g. class II and class III Angle anomalies). Also, the lateral cephalometric analysis helps us to examine the growth degree and direction of the maxillary upper and lower jaws [4]. Till recently, conventional 2-D radiographs were considered as the principal method to diagnose a maxillary impacted canine and for the careful elaboration of a treatment plan. Localisation of the impacted tooth is based on the parallax technique, which consists of the realisation of a separate radiograph that changes the mesio-distal direction of the Röntgen x-ray tube. A displacement of the impacted tooth in the same direction of the Röntgen tube signifies a palatal position of the tooth, a movement in the opposite direction shows the tooth having a vestibular position. 2-D radiographs have disadvantages such as: distortion, overlapping of the tissues, artifacts and insufficient volume of data offered to the practitioner. Consequently, they are not the ideal method for localisation and prognostic for maxillary impacted canines [5]. With new improvements such as CBCT imaging (cone beam computer tomography), practitioners have access to a multitude of information in relation to the maxillary bone pathology, including impacted teeth [6-10].

The KPG index is the first 3D classification system for impacted maxillary canines in report to their ideal position on the arch. This assumption is realised when a CBCT image is used to appreciate the X, Y and Z virtual space axes, position of the tip of the cuspid and the apex of the impacted maxillary canine. In function of localisation where both guidance points are compared to their ideal position, they are given a score between 0-5. The final score will place the impacted maxillary canine in accordance to its grade of treatment difficulty: easy (score 0-9), moderate (score 10-14), difficult (score 15-19), very difficult (score >=20). On the basis of this index the orthodontist can rapidly establish the level of difficultly faced in the treatment of the impacted canine and its estimated time of treatment [11,12].

The aim of this study is to evaluate the level of difficulty in the treatment of impacted maxillary canines using the KPG index for a study group of 32 CBCT's of impacted maxillary canines.

Experimental part

Materials and methods

A number of 32 CBCT's were provided by the radiologic and dental imaging facility Iso-X. These were gained through the use of a Vatech E-Woo Pax Reve 3D machine. Capturing the zones of interest in their three-dimensional space was done with a field of view (FOV) of 5X5 cm, 8X6 cm, 12X8 cm and 15X15 cm. The irradiation dose was minimal, high sensibility and exposure time of 0.3 s, all enabling for the obtainment of a correct 3D image. Images obtained were recorded electronically and together with the EZ 3D PLUS software were viewed, which allowed the doctor to study the concerned structures in all three spatial sections (coronal, sagittal, axial). When in need, magnification instruments were used, enlarging,

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measuring and capturing of the image were provided by the visual CBCT software. Amongst the 32 CBCT's that were analysed, only 28 of them were in accordance of the impaction criteria set by this study.

Criteria for impaction were represented by:

-Patients after having a CBCT analysis presented with one or both maxillary canines impacted;

-Teeth that remained impacted for a period of 1.5-2 years or more, after the physiologic age of eruption;

-Failure of eruption: A. Canine deeply impacted; B. Long axis of the canine modified; C. Lack of space necessary for eruption on the dental arch; D. Obstacle in eruption path; E. Absence or morphologic modifications of the lateral incisor that prevents the necessary eruption guidance of the canine; F. Larger dental follicle.

Every CBCT in part were analysed with the program named previously, following the variables stated below: 1.Age; 2.Gender (Female/Male); 3.Impacted tooth/teeth (unilateral/bilateral); 4.Score axis X; 5.Score axis Y; 6.Score axis Z; 7.Total score; 8.Grade of difficulty of treatment in function of the total score: easy (0-9)/ medium (10-14)/ difficult (15-19)/ very difficult (>20); 9.Type of impaction: hard tissue impaction/ soft tissue impaction/ partial eruption; 10.Lateral incisors form: normal/ absent/ conic; 11.Resorption of the neighbouring teeth: yes/ no; 12.Localisation of the resorption in accordance to the neighbouring teeth: central incisor, lateral incisor/ first premolar/ second premolar; 13.Localisation of the resorption in accordance to its para-radicular position: cervical third/ middle third/ apical third;

Steps followed whilst analysing every CBCT were:

A.Establishing the type of impaction: unilateral (right/ left) or bilateral;

B.Use of an orthopantomograph (OPT) on the basis of which axis X and Y were analysed, each having an attributable score that conforms to the KPG index method for analysis;

C.The final score results from the sum of the 3 individual scores obtained from X, Y and respectively Z axes (each being analysed by the tip position of the cuspid and that of the apex). Treatment difficulty is classified in 4 categories, in function of the obtained total score: 0-9 = easy; 10-14 = medium; 15-19 = difficult; >20 = very difficult;

D.Type of impaction: hard tissue impaction/ soft tissue impaction/ partial eruption;

E.Lateral incisors form: normal/ absent/ conic;

F.Resorption of the neighbouring teeth: yes/ no;

G.Localisation of the resorption in accordance to the neighbouring teeth: central incisor, lateral incisor/ first premolar/ second premolar;

H.Localisation of the resorption of the neighbouring teeth: radicular cervical third/ radicular middle third/ apical third;

Data collected was introduced into a table and analysed with a statistical analysis programme Numbers, version 3.6.1 (Mac OS X, Apple).

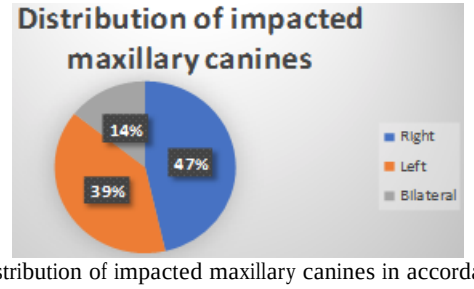

Fig. 1. Distribution of impacted maxillary canines in accordance to their localisation

This study of analysed CBCT's identified 32 impacted maxillary canines. With the distribution of the cases being in accordance to gender, out of the total number of cases, 10 were male and 18 were female. Also the distribution of the impacted canines being in accordance to their localisation unilateral (right/left) or bilateral on the dental arch can be seen in figure 1.

Results and discussions

Type of impaction was predominated towards palatal (78%) than vestibular (22%). The average age of patients being 17.07 years old, having up to a maximum age of 31 years old and a minimum age of 10 (table 1).

Table 1

AGE OF PATIENTS INCLUDED IN THE STUDY

Average age	17,07 years old
Maximum	31 years old
Minimum	10 years old

Analysis of the X axis for the cuspid tip of the 32 canines taken in this study, resulted in a number of 5 canines with a score of 1, 12 canines with a score of 2, 7 canines with a score of 3, 6 canines with a score of 4 and 2 canines with a score of 5.

Analysis of the X axis for the apex of the 32 canines taken in this study, resulted in a number of 2 canines with a score of 1, 14 canines with a score of 2, 10 canines with a score of 3, 5 canines with a score of 4 and 1 canine with a score of 5 (fig. 2).

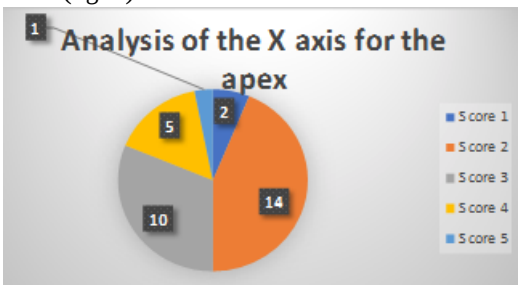

Fig. 2 Analysis of the X axis for the apex

In regards to the analysis of the Y axis for the cuspid tip, 6 canines had a score of 1, 13 canines had a score of 2, 8 canines had a score of 3, 4 canines had a score of 4 and 1 canine had a score of 5 (fig. 3).

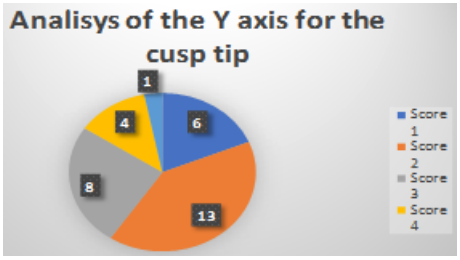

Fig. 3 Analysis of the Y axis for the cusp tip

Analysis of the Y axis for the apex of all 32 impacted canines fell within the score range of 0 (the apex situated in the normal vertical position).

The Z axis for the cuspid tip of the 32 canines analysed, resulted as follows: 5 canines with a score of 1, 6 canines with a score of 2, 11 canines with a score of 3, 5 canines with a score of 4 and 5 canines with a score of 5. For the apex of the Z axis, results showed 3 canines with a score of 0, 4 canines with a score of 1, 11 canines with a score of 2, 8 canines with a score of 3, 4 canines with a score of 4 and 2 canines with a score of 5 (fig. 4).

Grade of treatment difficulty was calculated based on a total score (0-9 easy, 10-14 medium, 15-19 difficult, >20

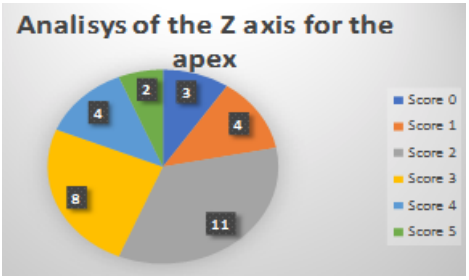

Fig. 4 Analysis of the Z axis for the apex

very difficult) obtained through an individual sum of the scores of the X, Y, Z axes. Thus in 16% of cases, the treatment was categorised with a difficulty of easy, 53% presented with a medium grade of difficulty and 31% were considered to fall within the difficult grade of treatment.

The lateral incisor form was normal in 94% of the total cases, whereas 6% of the cases presented with agenesis of the lateral incisor.

Classic radiology raised an issue for the orthodontist during the diagnostic stage of impacted teeth and its associated anomalies. Impacted teeth can be exactly evaluated with the help of CBCT imaging. Through this method of investigation the clinician can establish the exact position of the tooth in the bone and its relation to the surrounding structures, with the scope of establishing a correct and complete plan of treatment [13].

Orthodontics recently (2009) saw the development of the (KPG) index that utilises CBCT's for the classification of impacted canines. The rise in popularity of the CBCT imaging, together with a large prevalence of impacted canines, further accentuated the importance of the KPG index in the orthodontic field. Patients and their guardians from the very first appointment are keen to gain an estimative duration for treatment of the impacted canines. With the help of CBCT's and the KPG index, clinicians can very rapidly reproduce and determine the exact position of the canines, the gravidity of the impaction and estimated time of treatment [12]. The study at hand was realised on a number of 28 CBCT's, upon which 32 impacted canines were analysed. Distribution of the CBCT's was in accordance to gender, where 64.28% were female and 35.71% were male. With respect to the distribution of impacted canines in accordance to their localisation unilateral (right/left) or bilateral on the dental arch, the most frequent impaction was unilateral (46% on the right side and 39% on the left side), in comparison to bilateral impaction that was (14%). These results were in accordance with that obtained by Lai et al [14] in their study of 113 CBCT's (65.49% female vs. 34.51% male, having a higher frequency in unilateral impaction 81.4% vs. bilateral 18.6%). The average age of patients included in our study were of the age of 17 years old (with a maximum age of 31 years and a minimum age of 10), results that were likewise obtained in Lai et al study [14], where the respective average age was 19.35 years old. Three-dimensional analysis of the position of the 32 impacted canines indicated a frequency higher in a palatal impaction than that of a vestibular impaction (78% palatal vs. 22% vestibular) other studies also confirmed a higher percentage in cases that have a palatal impaction, in comparison to that of a vestibular impaction (69.4% palatal vs. 30.6% vestibular). A vestibular positioning denotes in general a space deficit on the dental arch, whereas a palatal positioning does not signify a deficit of space. The ethology of a palatal impacted canine can be attributed to genetic or local factors such as: the persistence of the temporary canines on the dental arch, late eruption of the permanent canines, absence or malformation of the lateral incisors, etc.

In the majority of cases analysed, the tip of the cuspid and the apex of the canines impacted had a score of 2 on the X axis (sagittal), their position being in the distal half of the lateral incisors crown, respective in the mesial half of the first premolar on the same hemiarch. Analysis of the Y axis (vertical) showed a majority score of 2 (cervical third of the root) for the cuspid tip and a score of 0 for the apex. Similar results were obtained in a study done by Lai C.S et al. [14], whereas the respective score of 2 was given for the positioning of the majority of the cuspid tips. All of the 32 canines had unanimous score of 0 for the position of the apex's in a vertical direction, this fact being explained by their origin being situated deep in the maxilla. To obtain a maximum score of 5 for the impacted tooth's apex to have a vertical direction, this would imply the tooth being anastrophe (having an inverse position, with the apex surpassing the neighbouring tooth's crown). Analysis of the Z axis was done by using an axial sectioned CBCT image that showed a majority score of 3 both for the cuspid tip as for the apex, more explicitly their localisation was either vestibular or palatal at a distance of 4-6 mm in comparison to the line that unites the marginal crest of the posterior teeth and anterior teeth, materialising the line for the ideal form of the respective dental arch.

The treatment difficulty grade was calculated based on a total score (0-9 easy, 10-14 medium, 15-19 difficult, >20 very difficult) obtained through an individual sum of the scores of the X, Y, Z axes. Most frequently recorded was that of a medium difficulty grade.

Resorption of the neighbouring teeth were difficult to diagnose and could not be always evaluated only by using the classic radiographic method that even if are easily utilised, they do not offer exact information on the position of the impacted tooth and the presence of resorption affecting the neighbouring teeth. There exist studies such as Lai et al. [14] where 134 impacted canines were studied; following the analysis of the CBCT images there was identified to be radicular resorption in 25.37% of lateral incisors and 5.22% of central incisors. In our study resorption of the neighbouring teeth was rarely found, having 3% of cases analysed showing some form of radicular resorption affecting the apical third of the lateral incisors.

The lacks of our study are represented by the followings:

-due to the absence of information in regards to the type of orthodontic treatment effectuated and of the exact duration of treatment, it was unable to realise a retrospective study to gain an appropriate comparison between estimated treatment time by the KPG index and that of the actually treatment time;

-a small number of CBCT's analysed, whereas a larger number would have had a more relevant statistical significance;

-the reproducibility of the KPG index can be influenced by the CBCT scanner used, thus size of the voxel and distance between the sections are not equal;

-there may exist small differences in data interpretation depending on the software utilised for viewing the CBCT, due to the characteristics possessed by each program used;

-data interpretation errors measuring the necessary evaluation of the KPG index and the clinical experience of the orthodontist having a role;

Conclusions

Precise position of the impacted canines and appreciation of resorption on neighbouring teeth can be correctly appreciated in 3D imaging. Utilising CBCT's is recommended for orthodontists and surgeons in order to establish a true diagnostic plan and a correct interdisciplinary treatment plan. Used as an additional supplementary form for clinical examination and conventional radiographs, CBCT imaging supplies exact information on the localisation of the impacted teeth and the grade of radicular resorption affecting the neighbouring teeth.

The KPG index has proven to be an efficient and effective instrument for the classification of impacted canines in accordance to their positioning. As soon as the CBCT program is opened, the time necessary to gain a score for every impaction case is short. Classification of the grade of difficulty of maxillary impacted canines and treatment time estimation are two very important aspects in the conception of the treatment plan, also the KPG index in time may permit the Orthodontist to achieve the maximum fidelity and reproducibility.

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