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Radiographic assessment of maxillary canine impaction

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ABSTRACT:

Aim-The aim of this study was to develop and validate a large-scale prediction model for impaction of maxillary canine based on linear and angular radiographic measurements.

Methodology- From the available database all patients with at least two panoramic radiographs recorded between the ages of 7 and 14 years with an interval of 1 to 3 years (T1 and T2) were selected. At T1, linear and angular readings were done. At T1, 572 patients with unilaterally or bilaterally impacted canine were chosen from 2361 records. Thirty-six patients remained untreated at T2 and were used as research participants. Logistic regression analysis was used to construct the prediction model.

Results- The backward method was used to examine pair wise intersection, canine to angle of midline, canine to angle of first premolar, cusp of canine to distance of midline and maxillary plane. An area under the curve equivalent to 0.783 (0.742 to 0.823) was applied to assess the possibility of impaction.

Discussion- The prediction model, which is applied to calculate the chances of canine impaction, is a suitable for early intervention and routine follow-up.

Keywords: Canine impaction; OPG, Linear measurement, Angular measurement.

INTRODUCTION:

After third molar, the most common impaction of the teeth is maxillary canine with 1-2.5% of prevalence most commonly affecting females.[1-3]There are various causes behind the impaction of maxillary canine like tooth material arch length discrepancy, overlying hard or fibrous soft tissues may obstruct the eruption path.[3,4] By the removal can enhance the capabilities of self-correction and eruption spontaneously.[3]

Becker et al., concluded an association between anomalies of maxillary lateral incisor and impaction of canine as various studies reported impaction prevalence increased with anomalies of lateral incisor.[3,4] It could be due to deflection in the guidance of the path of eruption because of defected lateral incisor.[3,5]On another hand, various other authors suggested it could be due to genetic factors and carried forward hereditarily.[5,6]

Early detection and treatment of impacted maxillary canine is critical because it cuts down cost of treatment and time, reduces the complication chances or negative effects, and improves orthodontic treatment modalities.[7]Various researches supported primary canine extraction facilitates spontaneous eruption of permanent canine.[8-12]The most common complication is resorption of root of lateral incisor and sometimes root of centrals also, others are pain, ankylosis, cyst and external or internal resorption.[5,13] By using alqerban et al., model present study was conducted to check their parameters, calculate the chances of canine impaction, early intervention and routine follow-up. The aim of this study was to develop and validate a large-scale prediction model for impaction of maxillary canine based on linear and angular radiographic measurements.

METHODOLOGY:

After taking the ethical approval for research protocol, 2,361 patients's database with two OPG taken between age 7 to 14 with interval of 1 to 3 years (T1& T2) were selected for the current research. Records with development defects (cleft lip and palate), erupted or extruded canine and poor quality radiographs were excluded.

Impaction assessment was done at T1 on 572 OPG (either unilaterally or bilaterally impacted canine) by volume of canine overlap to lateral incisor (sector) and angle of canine long axis and midline (3ML). Modified Ericson and Kurol's method used for sector measurement (Figure 1a).[14,15]If the sector was equal or more than 3ML, the maxillary canine presumed impacted.[16,17]Only 306 untreated patient's records were used for T2 assessment.

Demographic data was also collected for selected samples and both T1 and T2 OPG used for linear and angular measurement (Figure 1a &1b). Tooth long axis was used for the angular measurements. The midline used between the middle point between the two incisors and the anterior nasal spine. Amultiplication of the maxillary central incisor width at the contralateral side was done for linear measurements.[7] The canine cusp to the midline or to the maxillary plane distance was measured perpendicular to each plane, correspondingly. The maxillary occlusal plane was assessed by the incisal edge of the maxillary central incisor and the mesiobuccal cusp tip of the first maxillary molar on same side.

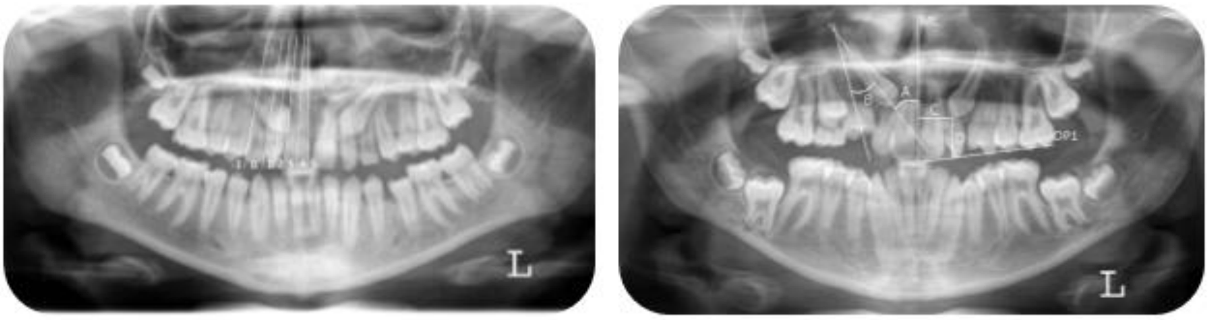

Figure 1- (a) Panoramic radiograph illustrating the sector of the canine. A modification of Ericson and Kurol's method was used. (b) Panoramic radiograph illustrating the angular measurements of the canine position in degrees, with (A) angle of maxillary canine to midline, (B) angle of maxillary canine to first premolar and linear measurements in mm with (C) canine cusp to midline distance, and (D) canine cusp to maxillary plane distance

The data was analyzed by applying logistic regression to generate a prediction model and model parameter estimation.

RESULTS:

Unilateral impaction was observed in 118 records and bilateral was in 188 at T1 (mean age 9.3±1.32 years), at T2 (Mean age 11±1.35 years) observed 40.69% of canine were impacted. A total of five potential predictor variables were chosen (Table 1). A model was developed using these parameters, except the finding with sector level 3. Table 2 displays the p values for the model variables that were chosen. The variables with p >.05 were also involved in the model since they are extent of one of the major correlations of variables (Table 2).

The final outcome was used to measure the probability of impaction, yielding an AUC of 0.783 (95 % confidence interval [0.742–0.823]; (Figure 2, Table 3).The cross-validated AUC was 0.750 (95 % confidence interval [0.700, 0.799]), indicating that the model performed reasonably well.The likelihood

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cut-off point was set at 0.342, with a sensitivity of 80 % and a specificity of 59.8%.When the expected probability of impaction (PI) exceeds 0.342, a canine is identified as impacted.

Variable	Statics	All
Patient Level at T1		
Total number of subject	N	306
Gender		
Male	N	154
Female	N	152
Age at T1	Mean	9.3 (SD 1.32)
	Range	7;13
Number of subject with impacted canines at T1		
Unilateral	N	118
Bilateral	N	188
Tooth Level at T1		
Tooth	N	490
13	N	240
23	N	254
Canine to first premolar angle (Degree)	Mean	11.1 (SD 12.2)
3 4	Range	0.0;110
Canine cusp to midline distance (mm)	Mean	171.3 (SD 27.5)
3c-ML	Range	88.9;271.2
Canine cusp to maxillary plane§ distance (mm)	Mean	174.2 (SD 40.6)
3c-OP1	Range	18.7;275.5
Canine to midline angle (degrees)	Mean	21.7 (SD 7.1)
3 ML	Range	2.4;77.8
Sector		
0	N	373
1	N	61
2	N	34
3	N	2

Table 1- Descriptive information based on patient level and on tooth level at T1 (OPG1). Angles are shown in degrees and distances in millimeters. The values for the angular and linear measurements refer to all canines irrespective of side

Effects	p value
3 4	**0.0004***
3c-ML	**0.9744**
3c-OP1	**0.5095**
3 ML	**0.0549**
Sector	**0.0441***
3 4, 3 4	**0.0007***
3 4, 3c-ML	**0.0256***
3 4, 3c-OP1	**0.0003***
3 4, Sector	**0.0064***
3c-OP1, Sector	**0.0368***

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Table 2: Selected model variables with *P* values

Effects	Sector level	Parameter estimate	Standard error
Intercept		-3.5494	3.0850
3 4		-0.5533	0.1582
3c-ML		0.0002	0.0066
3c-OP1		0.0199	0.0124
3 ML		0.0430	0.0224
Sector	0	0.2681	2.7491
Sector	1	1.5664	2.9732
Sector	2	5.9506	3.2249
3 4, 3 4		0.0025	0.0007
3 4, 3c-ML		0.0013	0.0006
3 4, 3c-OP1		0.0014	0.0004
3 4, Sector	0	-0.0324	0.0704
3 4, Sector	1	0.0520	0.0768
3 4, Sector	2	0.1172	0.0787
3c-OP1, Sector	0	-0.0064	0.0122
3c-OP1, Sector	1	-0.0181	0.0136
3c-OP1, Sector	2	-0.0388	0.0164

Table 3: Prediction model. To calculate the probability of impaction, the weighted sum of the predictor values (=μ), must be determined from the following multiple logistic regression model

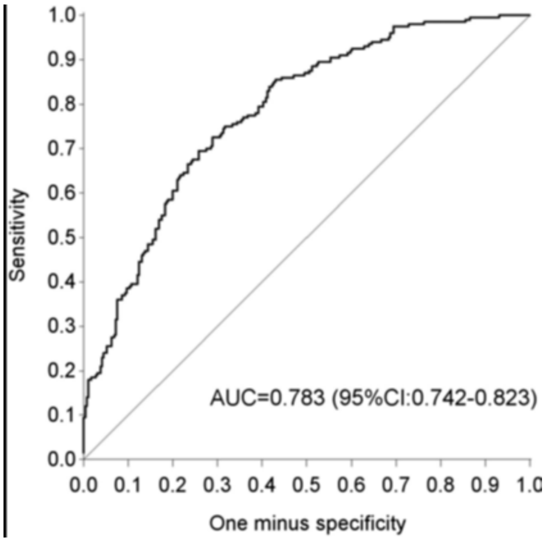

Figure 2- Receiver operating characteristic curve based on the multiple logistic regression analysis. It represents the sensitivity and (one minus) specificity of all possible classifications using different cut-offs for the predicted probability of maxillary canine impaction. The optimal cut-off point of probability is equal to.342 with a sensitivity of 80 % and a specificity of 59.8%

Reassurance of the previous prediction model with the current sample yielded a reasonable result, with an AUC of 0.594 (95 percent CI [0.544, 0.645]). The intraclass correlation coefficients were observed to be very high, representing very decent to exceptional inter-rater and intra-rater measurement reliability. Intra-rater reliability was 0.870 [0.840, 0.895], 0.920 [0.900, 0.935], 0.927 [0.909, 0.941], and 0.973 [0.966, 0.978] for 3 4, 3c-ML, 3c-OP1, and 3 ML, individually, with 95 % confidence intervals of 0.870 [0.840, 0.895], 0.920 [0.900, 0.935], 0.927 [0.909, 0.941], and 0.973. Inter rater reliability was 0.954 [0.931, 0.970], 0.959 [0.938, 0.973], 0.943 [0.915, 0.963], and 0.984 [0.975, 0.989] for 34, 3c-ML, 3c-IP1, and 3ML, individually, with 95 % confidence intervals of 0.954 [0.931, 0.970], 0.959 [0.938, 0.973], 0.943 [0.915, 0.963], and 0.984.

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DISCUSSION:

Since the risk of root resorption of adjacent permanent incisors increases with impaction of canine, it would be beneficial to develop a new prediction model for impaction maxillary canine toearly diagnose. Numerous researchers have proposed different criteria for distinguishing impaction of canine over the years.[4,7,15,18-20] To assess the impaction sector and 3ML were used which were considered powerful predictor for impaction.[17,21] Variables 3c-OPI, 3 4 and 3c-ML were also used to support the new model of prediction.

3 4 and sector were confirmed as independent variables, and interactions were observed during the model fitting process (Table 2).Since they were important at the $p<0.05$ level or were part of an interaction, they were included in the final prediction model.Several studies have analyzed quantitatively each parameter, but this is inadequate to reliably analyze such a complex dataset.[22,23]The parameters were analyzed for quadratic patterns and pairwise interactions in this analysis, allowing for a reduction in the amount of information while maintaining useful details about each measure.According to Uribe et al., study is more efficient when multivariable data analysis is used.[24] The new model was built without the findings of Sector 3, allowing interactions of other variables with sector.Attributed to the reason that only two measurements used for Sector 3, model fitting would be inconsistent if interactions with sector were included.In addition, canines impaction in Sector 3 are more likely to be, so a prediction model isn't required in such situations.[17]

For the various potential cut-off points of the current diagnostic tests, the linear regression curves indicated the true positive rate versus the false positive rate (Figure 2).Any reduction in specificity would result in an upsurge in sensitivity.The current prediction model had a discriminative potential of 78.3 percent. For maximization of sensitivity, the cut-off value was set to 0.342.This value was followed by an 80% sensitivity rate, implying that 20% of the non-impaction predictions would be incorrect.Besides, non-impacted teeth were correctly detected in 59.8% of cases.As a result, 40.2 % of the cases were found to be false positive.It explains that if the impaction is planned to be handled, the risk of overtreatment should be considered.

OPG are often used in dentistry for diagnosis.The aim of this study was to develop aimpaction diagnosis system based on available OPG, so that potentially impacted maxillary canines could be treated early.Despite these challenges, two-dimensional radiographs have a variety of well-known drawbacks, including magnification, information loss, overlapping and blur.[25]As a result, if errors occur while radiographic imaging, the analysis of readings on OPG can be exaggerated.[26]The most common form of error in OPG is improper patient positioning, which result in poor-quality radiographs.[26,27]When comparing traditional OPG to 3D imaging, inaccuracies due to head positioning effects are higher.[28]McKee et al. looked at how patient positioning errors affected OPG and found that most of angle of images were different significantly in deviated patient's positions[29]which is supported by Nikneshan et al.[30]However, patient orientation errors and intrinsic image distortions should be taken into account when interpreting angular measurements on panoramic images.[26,29]

Above mentioned issued can ignored by using 3D-imaging. While cone-beam computed tomography (CBCT) has established itself as the gold standard for precise diagnosis of maxillary canine impaction and surrounding bone, and can also be used to perform linear and angular measurements.[13,25,31-35]Despite this, it appears that various diagnostic methods, such as apical radiograph measurements, produce different outcomes.[14,20]As a result, while this prediction model may be beneficial in practices that use similar diagnostic and follow-up techniques, it should not be considered standard guidelines.

Another major weakness in the current research is that it was conducted retrospectively.As a consequence, in clinical environments, it's important to carefully interpret the findings.A prospective follow-up of a possible impaction will provide further information and validate the diagnosis. This research validated both the old and new formulas to address this shortcoming.In a new sample, the cross-validated AUC provides an accurate estimation of the model's predictive validity.This is to find reasons for the overconfidence. The old model was validated with the new dataset, yielding a very low AUC index of 0.594.The broad sample size of this study is one of its strengths. Selecting one tooth out of two in the group of 188 patients with both maxillary impacted canines at random would have resulted in a smaller sample, resulting in less power and, thus, a more accurate model. As a result of such a random collection, no bias is required.

Additional measures in the detection of canine impaction, such as the practitioners' clinical expertise and particular patient factors (age, gender), continue to play a significant role.Family history, visual examination (deep bite, narrow maxilla, over-retention of the primary canine, anomalies of lateral incisor), tactile clinical examination (absence of the canine bulge), and other radiographic indicators (enlarged follicular sac, lack of resorption of the primary canine) are all relevant factors to consider.These red flags should be investigated further, maybe using the prediction formula.Besides that, the treatment option is determined by the patient's age. At the age of 7, a maxillary canine would not be subjected for surgical exposure.Despite these drawbacks, developing a prediction model for impaction of maxillary canine is crucial in clinical practice.Based on the current panoramic radiograph, the present prediction formula will assist the practitioner in making an objective scientifically-based decision and predicting the existence of impaction.A prospective research strategy is required to identify this prediction model. These variables can also be studied using CBCT for more accurate measurements.

According to Alqerban, CBCT may be a strong diagnostic method for canine impaction detection. Despite the limitations of panoramic radiographs, they are still routinely used for pre-orthodontic diagnostics in our country, which is why they are included in our research.It may also be agreed to take an alternate CBCT based on the panoramic image. Additional parameters associated with the etiology of impacted canines, such as arch length deficiency, need to be investigated further.

CONCLUSION:

The final prediction model based on radiological parameters calculated on OPG was presented in this research. Since OPG are regularly taken for pre-orthodontic diagnosis, the aim is to provide a clinically accurate scenario for orthodontists to help predict potential issues with the maxillary canines.The model can be used to choose between early intervention and routine follow-up of canines that appear to be affected. It may aid in the correction of problems or warn of the risks of not handling them. The new model's testing revealed that detecting impaction of maxillary canine on OPG is a useful method.

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