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BIANCA HECK

CONFIABILIDADE DE FATORES CLÍNICOS NA PREDIÇÃO DE CANINOS POTENCIALMENTE IMPACTADOS

Porto Alegre
2021

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Bianca Heck

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“Aqueles que se sentem satisfeitos sentam-se e nada fazem. Os insatisfeitos são os únicos benfeitores do mundo.” (Walter S. Landor)

RESUMO

HECK, B. **Confiabilidade de fatores clínicos na predição de caninos potencialmente impactados**. Dissertação (Mestrado em Clínica Odontológica – Ortodontia) – Faculdade de Odontologia, Universidade Federal do Rio Grande do Sul, Porto Alegre, 2021.

Introdução: O objetivo deste estudo retrospectivo foi avaliar a hipótese nula de que não há diferença na posição, tamanho e forma da coroa clínica do incisivo lateral superior, assim como nas dimensões transversais e verticais da maxila, em pacientes de baixo risco com e sem caninos potencialmente impactados. **Material e método:** O estudo baseou-se em radiografias panorâmicas e modelos de gesso de pacientes com caninos em posição normal (NC), que consistiu de 60 caninos com a coroa posicionada no setor I, e o grupo de caninos deslocados (DC), composto por 41 caninos potencialmente impactados (setores II, III ou IV). Os modelos de gesso foram digitalizados para análise das variáveis quantitativas e qualitativas da coroa clínica dos incisivos laterais superiores (dimensionais, posicionais e características morfológicas). Além disso, dimensões transversais e verticais do arco dentário também foram medidas. Os grupos foram comparados com os testes *t* de Student, qui-quadrado e teste U de Mann Whitney. **Resultados:** Houve associação significativa entre sexo e caninos ectópicos. Caninos ectópicos unilaterais foram mais prevalentes do que bilaterais. As características de posição das coroas dos incisivos laterais superiores mostraram estes dentes significativamente mais angulados para mesial e com rotação mesiolabial no grupo de pacientes de baixo risco com caninos ectópicos, os quais também apresentavam redução nas medidas de dimensão transversal e do comprimento anterior da maxila. A angulação e rotação da coroa, assim como a profundidade palatina e o comprimento do arco foram significativamente correlacionados com a severidade de deslocamento dos caninos. O modelo de regressão previu um terço dos casos de caninos impactados. **Conclusões:** A hipótese nula foi rejeitada. A angulação da coroa dos incisivos laterais superiores inconsistentes com a ‘fase do patinho feio’ foi o mais importante preditor da posição ectópica dos caninos em pacientes de baixo risco, contribuindo assim para o seu diagnóstico precoce.

Palavras Chave: Ortodontia Preventiva; Erupção Ectópica de Dente; Dente Canino; Diagnóstico Clínico; Diagnóstico por Imagem; Radiografia Panorâmica

ABSTRACT

HECK, B. **Reliability of clinical factors to predict potentially impacted canines**. Dissertação (Mestrado em Clínica Odontológica – Ortodontia) – Faculdade de Odontologia, Universidade Federal do Rio Grande do Sul, Porto Alegre, 2021.

Objective: This retrospective study's goal was to evaluate the null hypothesis that there is no difference in position, size and shape of the clinical crown of the maxillary lateral incisor as well as in transverse and vertical dimensions in low-risk patients with and without potentially impacted maxillary canines. **Material and method:** Study was based in panoramic radiographs and dental casts of patients with canines in normal position (NC), that consisted of 60 normally erupting canines with the crown positioned in sector I, and the displaced canine group (DC), comprising 41 potentially impacted canines (sectors II, III or IV). Dental casts were scanned to analyze the quantitative and qualitative variables of the clinical crown of maxillary lateral incisors that were dimensional, positional, and morphological characteristics. In addition, transverse and vertical dental arch dimensions were also measured. Groups were compared with Student's *t*-tests, chi-square tests and Mann Whitney U test. **Results:** There was a significant association between sex and mesially displaced canines. Unilateral ectopic canines were more prevalent than bilateral ones. Positional characteristic of the maxillary lateral incisor crown showed that it was significantly more mesially angulated and mesiolabially rotated in the group with displaced canines wich also presented a reduction in transverse arch dimensions and arch length. Crown angulation and rotation, as well as the transverse and vertical dimensions of the dental arch were significantly correlated with the severity of canine displacement. The regression model predicted a third of the cases of impacted canines. **Conclusions:** The null hipoteses was rejected. Maxillary lateral incisor angulation inconsistent with the "ugly duckling" stage was the most important predictor of canine ectopic eruption in low-risk patients, significantly contributing to its early diagnosis

Keywords: Preventive Orthodontics; Ectopic Eruption; Canine tooth; Clinical Diagnosis; Diagnostic Imaging; Panoramic Radiography

SUMÁRIO

1. INTRODUÇÃO

Os caninos são o grupo de dentes mais sujeitos à impacção, após os terceiros molares, com prevalência entre 0,2% a 2,8% (1-3), sendo de duas a três vezes mais frequente em mulheres do que em homens (3-7) e, na maior parte dos casos, apresentam-se no lado palatino (PDC).(1, 7)

A etiologia da impacção do canino ainda não está bem esclarecida, sendo aceita como multifatorial (8, 9), porém duas teorias já foram propostas: a “teoria do guia de erupção” defende que a impacção dos caninos ocorre por alterações em fatores locais tal como perda ou alteração da sua guia de erupção pelo dente adjacente, o incisivo lateral. Em contrapartida, a “teoria genética” se refere a existência de certos marcadores genéticos que resultam na falha de erupção normal do canino, assim como em outras anomalias dentárias associadas. (3, 6, 9-12)

Durante seu trajeto normal de erupção, o canino permanente superior se move em direção oclusal em contato íntimo com os dentes vizinhos: por mesial, o incisivo lateral, e por distal, o primeiro premolar.(13) A inclinação deste dente em relação à linha média atinge o ângulo máximo aproximadamente aos 9 anos de idade e após essa idade o ângulo reduz gradualmente com o movimento distal da ponta de cúspide.(13) Quando esse dente apresenta angulação e deslocamento mesial excessivos, ultrapassando os limites das raízes dos dentes adjacentes e se sobrepondo às mesmas, suspeita-se de uma alteração do padrão de erupção do canino, baseado em alguns critérios radiográficos já publicados.(1, 13-16) Lindauer *et al*.(17) realizaram um estudo retrospectivo com radiografias panorâmicas para definir a posição dos caninos intra-ósseos em relação aos dentes adjacentes e seu potencial de impacção. Foi verificado que 78% dos caninos impactados exibiam inicialmente sobreposição de imagem com a raiz dos incisivos laterais, enquanto que no grupo controle, sem impacção, apenas 4% dos caninos exibia algum tipo de sobreposição radiográfica com os dentes adjacentes.

É de extrema importância o diagnóstico e tratamento precoces para interceptar a posição ectópica dos caninos superiores e reestabelecer o processo fisiológico de erupção deste dente de forma a diminuir o risco de impacção ou de reabsorção dos dentes permanentes adjacentes, principalmente os incisivos laterais.(8, 15, 18) De fato, as sequelas relacionadas à erupção ectópica dos caninos superiores são esteticamente e funcionalmente devastadoras para o paciente, sobretudo se considerarmos a possibilidade de perda dos incisivos superiores, além do risco de

falha no tracionamento ortodôntico de um canino severamente impactado.(16, 19-21) Estas situações acabam por determinar a necessidade de tratamentos ortodônticos complexos, de longa duração e alto custo, uma vez que estão frequentemente associados à demanda de implantes e reabilitação protética. Assim, diversos protocolos de tratamento para a interceptação de caninos potencialmente impactados já foram propostos na literatura, como por exemplo a extração de caninos e/ou 1os molares superiores decíduos, prevenção da migração mesial fisiológica dos molares permanentes por meio de barra transpalatina e arco extrabucal, além da expansão rápida da maxila (ERM).(22-33) Além disso, diversas associações dessas terapias têm sido propostas na literatura, com resultados satisfatórios, sendo que em 2018 Barros *et al.* publicaram importantes diretrizes clínicas para a normatização da escolha do protocolo de tratamento a ser aplicado em diferentes situações clínicas, conforme ilustrado a seguir. (23)

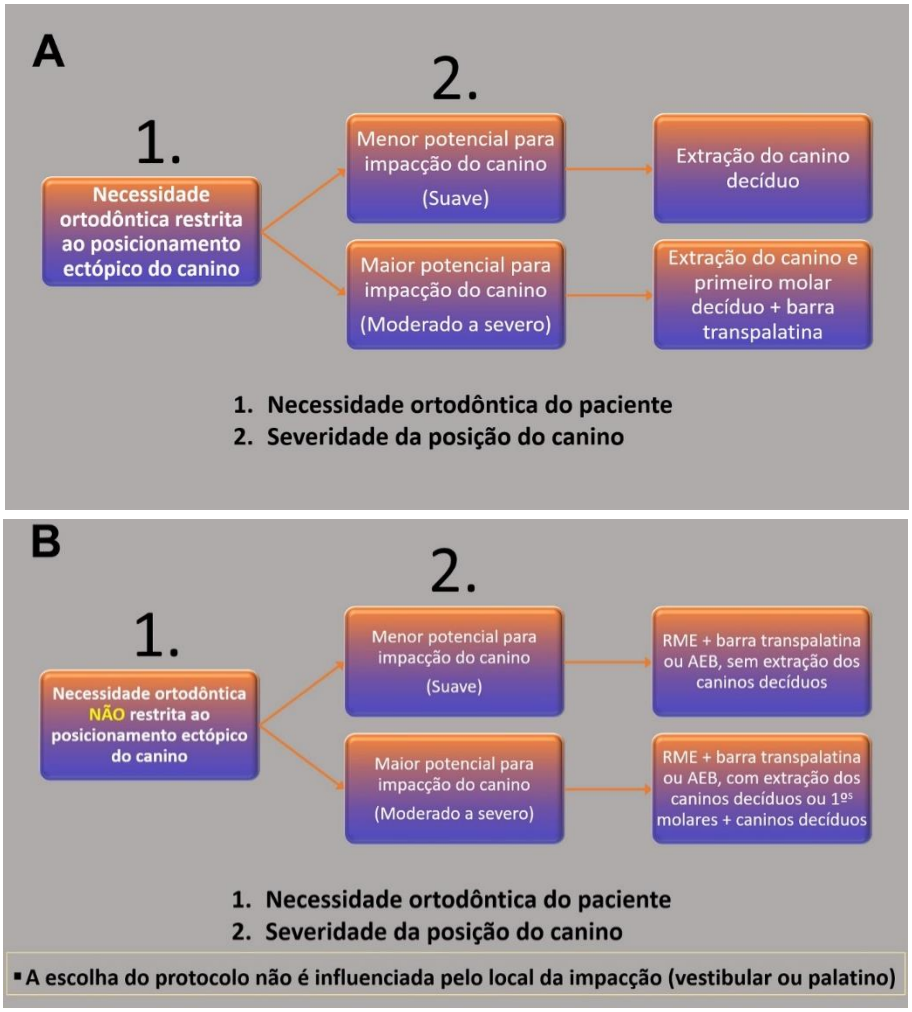

Figura 1- Sistematização da escolha do protocolo de tratamento, considerando a necessidade ortodôntica total do paciente e a severidade da posição do canino. **A.** Necessidade ortodôntica do paciente restrita ao canino. **B.** Necessidade ortodôntica do paciente não restrita ao canino.

Sabe-se que o diagnóstico precoce das anomalias de erupção dos caninos superiores, bem como do risco de sua potencial impacção, apenas pode ser plenamente realizado mediante exames de imagem que permitam a visualização intra-óssea do posicionamento deste dente.(34) Contudo, faltam diretrizes bem definidas para saber quando indicar exames radiográficos complementares, pois caracterizaria um sobrediagnóstico solicitar radiografias de todos os pacientes na fase de dentadura mista sob a premissa de uma provável existência de problemas eruptivos dos caninos superiores, haja vista a prevalência deste problema na população.(10, 35-37) Além disso, a indicação de exames radiográficos para pacientes nesta faixa etária deve ser extremamente criteriosa devido a radiossensibilidade aumentada dos tecidos jovens, além dos efeitos cumulativos das radiações ionizantes.(38, 39) Por outro lado, a negligência na realização deste diagnóstico pode produzir resultados extremamente nefastos e permanentes à dentição, oclusão e estética do paciente.(16, 19-21) Estudos prévios avaliaram a relação entre caninos superiores impactados e algumas características dento-esqueléticas dos pacientes, como as anomalias dos incisivos laterais (7, 40-43), agenesia do segundo premolar (7, 40, 43) e atresia do arco dentário. (44, 45) Entretanto, o posicionamento, o tamanho e a forma da coroa clínica do incisivo lateral nunca foram reunidos dentro de um modelo de regressão para avaliar o seu valor preditivo no pré-diagnóstico e na indicação da necessidade de exames radiográficos complementares com o intuito de prevenir a impacção de caninos em pacientes na fase de dentadura mista. Este procedimento poderia facilitar o diagnóstico precoce do canino superior ectópico, além de evitar expor desnecessariamente o paciente jovem à radiação ionizante.

Diante deste cenário, a proposta deste estudo é avaliar a eficácia de fatores clínicos como a posição, o tamanho e a forma da coroa clínica do incisivo lateral superior, assim como as dimensões do arco dentário superior no pré-diagnóstico de caninos potencialmente impactados e na determinação da necessidade de exames radiográficos complementares.

2. OBJETIVOS

2.1 OBJETIVO GERAL

O estudo tem como objetivo avaliar se há diferença na posição, tamanho e forma da coroa clínica do incisivo lateral superior, assim como nas dimensões transversais, comprimento anterior da arcada e profundidade do palato em pacientes de baixo risco com e sem caninos potencialmente impactados.

2.2 OBJETIVOS ESPECÍFICOS

- Definir parâmetros clínicos de pré-diagnóstico em pacientes de baixo risco que apontem a necessidade de exames radiográficos complementares para investigação da impacção dos caninos superiores.

3. ARTIGO

Esse trabalho de dissertação é composto pelo artigo **“Can pottentially impacted canines be early predicted in low-risk patients?”.**

Será enviado para publicação no periódico *American Journal of Orthodontics and Dentofacial Orthopedics*. O manuscrito, na formatação exigida pelo periódico correspondente, encontra-se a seguir:

CAN POTENTIALLY IMPACTED CANINES BE EARLY PREDICTED IN LOW-RISK PATIENTS?

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ABSTRACT

Objective: To evaluate the null hypothesis that there is no difference in the position, size, and shape of the clinical crown of the maxillary lateral incisor, as well as in the dental arch dimensions, in low-risk patients with and without potentially impacted canines. **Methods:** The normal canine position group (NC) consisted of 30 patients with 60 normally erupting canines ranked in sector I (age, 9.30 ± 0.94 years). The displaced canine group (DC) comprised 30 patients with 41 potentially impacted canines ranked in sectors II to IV (age, 9.46 ± 0.78 years). Maxillary lateral incisor crown angulation, inclination, rotation, width, height, and shape, as well as palatal depth, arch length, width, and perimeter, were evaluated on digital dental casts. Statistical analyzes consisted of group comparisons and variable correlations ($P<0.05$). **Results:** There was a significant association between sex and mesially displaced canines. Unilateral canine displacement was more prevalent than bilateral displacement. Maxillary lateral incisor crown was significantly more mesially angulated and mesiolabially rotated in low-risk patients with displaced canines, who also had a shallower palate and shorter anterior dental arch length. Lateral incisor crown angulation and rotation, as well as palatal depth and arch length, were significantly correlated with the canine displacement severity. The regression model predicted one-third of canine impaction cases. **Conclusions:** The null hypothesis was rejected. Maxillary lateral incisor angulation inconsistent with the “ugly duckling” stage was the most important predictor of canine ectopic eruption in low-risk patients, significantly contributing to its early diagnosis.

Introduction

Canines are the group of teeth more prone to impaction after third molars. Canine impaction is two to three times more frequent in women than in men.[1-5] Following its normal eruption pathway, the maxillary canine moves in an occlusal direction in close relationship with neighboring teeth. The canine angulation to the midline reaches its maximum tipping around 9 years of age.[6] From this development stage, the maxillary canine eruption path presents a gradual verticalization due to the distal movement of its cusp tip.[6] Maxillary canines with excessive mesial angulation and displacement, exceeding the limits of adjacent roots and overlapping them, have been considered potentially impacted.[7-9]

The sequels related to the ectopic eruption of maxillary canines can be aesthetically and functionally devastating for the patient, especially when considering the risk of maxillary incisors loss,[10] as well as the possibility of failure in orthodontic traction of a severely impacted canine.[11] These clinical conditions end up determining the need for complex, long-term, and costly orthodontic treatments.[12-15] Several protocols for the early treatment of potentially impacted canines have already been proposed and evaluated in the literature.[9,16-22] Recently, it was published a clinical guideline to assist clinicians in choosing the most appropriate early treatment protocol to be applied in different clinical situations of potentially impacted maxillary canines.[17]

Although relevant benefits of interceptive treatment in early mixed dentition have already been evidenced,[9,16-22] the early diagnosis of potentially impacted canines is not always performed on time.[10] Perhaps, because canine ectopic eruption is a silent, hidden developmental problem that may have associated genetic or environmental risk factors.[3,23] A previous study reported that in a sample of palatally displaced canines, 48% of patients had some maxillary lateral incisor anomaly, including peg-shaped, small, or absent lateral incisor, while 52% of them did not.[24] Thus, even when risk factors can not be identified, maxillary canine ectopic eruption should not be discarded, and local clinical signs produced by canine ectopic position should be prioritized to evaluate the need for a supplementary radiographic examination.[25-28] This is especially true for young patients with no objective treatment need, who can represent a significant percentage of the population.[29] The systematic indication of a radiographic examination at this age just to exclude an eventual canine eruption deviation can be considered controversial since the canine impaction prevalence is around 0,2% to 2,4%.[3,30] Radiographic examination of patients in mixed dentition should be carefully indicated due to the increased radiosensitivity of young tissues and the cumulative effects of ionizing radiation.[31,32]

Despite its great diagnostic relevance, the clinical signs associated with potentially impacted canines at an early age may be subtle and less well known than the widely reported radiographic findings.[7-9,33-36] From radiographic studies, it is known that the maxillary lateral incisor characteristics can both influence and be influenced by the maxillary canine eruption pathway.[8,37,38] According to Ericson and Kurol[26] criteria, 8% of children over 10 years of age may require a supplementary radiographic examination when clinical signs are carefully taken into account. Thus, some known clinical signs associated with genetic and environmental risk factors like anomalies of size, number, and form of the maxillary lateral incisor, dental arch narrowing, tooth size-arch length discrepancy, and palate dimensions should be evaluated to support the clinicians' decision for the need of complementary radiographic examination[23,24,26,27,39-44] However, low-risk patients may have more restricted clinical signs, as most of the known genetic and environmental risk factors are not present. As far as we know, no other non-radiographic study has excluded known genetic and

environmental risk factors in order to evaluate whether clinical signs may still be able to predict mesially displaced canines in low-risk patients. Given this scenario, the objective of this study was to evaluate the null hypothesis that there is no difference in the position, size, and shape of the clinical crown of the maxillary lateral incisor, as well as in the dental arch dimensions, in low-risk patients with and without potentially impacted canines.

Materials and Methods

This investigation was based on retrospective data obtained from orthodontic records of patients who sought treatment at the Faculty of Dentistry, University of _____, and the Orthodontic Service of the Military Polyclinic at _____. It was approved by the corresponding institutional review board, under number 3.976.250. The sample size calculation was performed assuming the values of 5% and 20% for α (Type I error) and β (Type II error), respectively. The minimum difference to be detected in the maxillary lateral incisor angulation of patients with and without potentially impacted canines was 5°, given that this difference is clinically perceptible. Standard deviation (8°) was taken from a previous study.[17] Sample size calculation indicated that a minimum of 32 canines in each group was needed.

Sample selection was based on the following inclusion criteria: good quality of orthodontic records, panoramic radiographs and dental casts taken on the same date, mixed dentition stage, ectopic eruption pathway or bilateral normally erupting maxillary canines in Nolla's developmental stages 7 or 8,[45] erupted permanent maxillary lateral incisors in Nolla's developmental stages 8 to 10.

Exclusion criteria were maxillary lateral incisors restoration or reshaping, maxillary anterior crowding greater than 2mm, syndromic patients, cyst or any other periapical lesion in the maxillary anterior segment, patients with cleft lip and/or palate, anomalies of size, number or shape of permanent maxillary anterior teeth, previous orthodontic treatment, patients with a history of prolonged sucking habits and anterior dental arch narrowing, history of dental trauma, early loss of deciduous maxillary canines or molars. All orthodontic records that met these criteria were included in this study.

The normal canine position group (NC) consisted of 30 patients with 60 normally erupting canines with the crown positioned in sector I, while the mesially displaced canine group (DC) consisted of 30 patients with 41 potentially impacted canines with the crown positioned in sectors II, III, or IV according to the radiographic method described by Lindauer *et al.*[7] Canines positioned in sector II should also have the angle between the long axis of canine and the midline (α angle) equal to or greater than 30 degrees,[46] and/or cusp tip positioned in the apical radicular third of the adjacent maxillary lateral incisor as additional severity aggravating factors. The NC group had a mean age of 9.30 years (16 females and 14 males) and the DC group had a mean age of 9.46 years (23 females and 7 males), totalizing 101 evaluated canines that were selected from the total number of consecutive orthodontic records from two-center orthodontic files.

The maxillary dental casts were digitized using a 3Shape 3D scanner (3Shape A/S, Copenhagen, Denmark) and the obtained 3-dimensional images were stored in a .stl file format. The measurements of the lateral incisor positional and dimensional characteristics, as well as dental arch dimensional characteristics, were performed on the digital dental models using the OrthoAnalyzer 3D software (3Shape A/S), as shown in Figures 1 and 2. In addition, the clinical crown of the maxillary lateral incisor was classified according to its morphological characteristic (ovoid, square, and triangular).

Lateral incisor angulation, inclination, and rotation were evaluated taking as reference the occlusal plane passing through the right and left mesiobuccal cusp tips of the permanent maxillary first molars, and through a point located at the mesioincisal angle of the left central incisor. The long axis of the maxillary lateral incisors was represented by an arrow in the virtual setup module of the OrthoAnalyzer software (Figs 1A and 1B). To determine tooth angulation, this arrow was mesiodistally manipulated on the buccal side, adjusting it to the facial axis of the clinical crown (FACC) defined by Andrews (Fig 1A).[47,48] From a distal view of the maxillary lateral incisor, the arrow was buccolingually manipulated at Andrews' facial axis point to determine the crown tipping, according to Andrews (Fig 1B).[47,48] Mesiodistal and buccolingual angular position of the maxillary lateral incisor was determined by the angle between the arrow and the occlusal plane, which was automatically calculated by the software (Figs 1A and 1B). The axial rotation of the maxillary lateral incisor was determined by the angle between the line passing through the incisal edge of the lateral incisor and the mid-palatal raphe, which were projected on the occlusal plane (Fig 1C).

The mesiodistal width of the maxillary lateral incisor was represented by the greatest distance between the mesial and distal contact points parallel to the incisal surface (Fig 1D). The clinical crown height was measured as the distance between the incisal and cervical limits of the facial axis of the clinical crown (FACC, Fig 1E). [47,48] The distance between the cervical limit of the facial axis of the clinical crown and the corresponding cervical limit on the palatal side was measured to determine the buccolingual width of the maxillary lateral incisor (Fig 1F).

Palatal depth was measured from a line passing through the mesial gingival papilla of the right and left permanent first molars to the deepest point on the palatal surface (Fig 2A). The maxillary anterior arch length was measured perpendicularly in the occlusal plane from the mesial aspect of the right and left deciduous first molars to a midpoint between the central incisors (Fig 2B). The transverse dimensions of the maxillary dental arch were represented by the intercanine and intermolar distances, which were measured between the cusp tips of the right and left deciduous canines and between the mesiobuccal cusp tips of the right and left molars (Fig 2C). The hemiarch transverse distances were measured perpendicularly from the same dental landmarks to a sagittal plane passing through the palatal raphe (Fig 2D). The anterior perimeter of the maxillary dental hemiarch was measured in the occlusal plane from the mesial contact point of the deciduous first molar to a midpoint between the central incisors (Fig 2B).

The measurements were performed by the same examiner (K.C.), who was blinded to selection criteria and group allocation. To evaluate the error of method, 30 study models were randomly selected and submitted to a second measurement performed by the same examiner. Intraclass correlation coefficient (ICC) was used to assess intra-examiner reliability and reproducibility for all linear and angular measurements.

Statistical analyses

The Shapiro Wilk test was used to check data normality. Intergroup comparisons were performed with *t*-tests, Mann Whitney U tests, and chi-square tests.

The mesial displacement severity of the maxillary canine was correlated with the discriminant variables between the groups using Spearman’s correlation tests.

Multiple linear regression analysis was used to predict the ectopic eruption of the maxillary canines based on a regression model grouping discriminant parameters.

All statistical tests were carried out using Statistica software (Version 7.0; StatSoft Inc., _____), adopting a significance level of 5%.

Results

Intraexaminer measurement reliability was considered good to excellent. The intraclass correlation coefficient ranged from 0.898 (C-O height) to 0.998 (intercanine width).

The groups were similar regarding chronological age. The group with displaced canines had a mean mesial displacement severity located between sectors 2 and 3 (2.46 ± 0.66). A significant association between sex and mesially displaced canines was observed, as 78.05% of the potentially impacted canines occurred in women. Unilateral canine displacement was more prevalent than bilateral displacement. There was a balanced proportion of unilaterally displaced canines between the right and left sides (Table I).

The evaluation of the positional characteristics showed that the maxillary lateral incisor crown was significantly more mesially angulated (uprighted) and mesiolabially rotated in the group with displaced canines. The dimensional and morphological characteristics of the maxillary lateral incisors crowns were not different between the groups. Comparisons of the dental arch dimensions showed that the displaced canine group had a shallower palate and a shorter maxillary anterior arch length (Table II).

There was a significant positive correlation between the severity of mesial displacement of the maxillary canine and the angulation of the maxillary lateral incisor, while a significant negative correlation was found between the canine displacement severity and lateral incisor rotation, palatal depth, and anterior arch length (Table III).

Maxillary lateral incisor angulation, palatal depth, and patient sex significantly contributed to predicting ectopic eruption of maxillary canines. Lateral incisor angulation was the variable with the greatest predictive strength. One-third of canine impaction cases in low-risk patients can be predicted based on this regression model (Table IV).

Discussion

Several studies have been carried out to identify early radiographic predictors of maxillary canine impaction.[1,8,35,36,49,50] This is because the delayed treatment of maxillary canine impaction is more costly, complex, and risky than early intervention, making its results less predictable.[11-15] The diagnosis of canine ectopic eruption begins with recognition of its clinical signs, which can be decisive in supporting the need for radiographic examinations.[26-28] This is especially true for young patients with no prior radiographic examination, no known genetic or environmental risk factor, and no orthodontic need. In these patients, there is a greater risk of ectopic eruption of the maxillary canine advancing as a silent, hidden, and mutilating development problem if clinical signs are not carefully evaluated to determine the need for complementary radiographic examination. Therefore, this study aimed to identify early clinical features that should raise clinicians' suspicion for the maxillary canine ectopic eruption in low-risk patients, which should be radiographically confirmed.[26] The standardized rhizogenesis stage established for sample selection contributed to the similarity of the groups' age (Table I), which is an important comparability parameter, as the canine position and its relationship with adjacent structures are sensitive to the patient's age.[6,43] The sample characteristics of this study confirm previous reports of an unequal distribution between the sexes with a higher prevalence rate among women, a lower prevalence for bilaterally displaced canines, and an almost equal distribution of

unilaterally displaced canines between the right and left sides (Table I).[3,24,51-53] Although the familial history of canine impaction can not be retrieved in this retrospective study, the genetic component associated with ectopic canine inheritance has low penetrance,[54,55] and its expression is often associated with maxillary lateral incisor anomalies,[24,39,56] which were excluded from this study.

The results showed that the position (angulation and rotation) of the maxillary lateral incisor crown was more mesiodistally uprighted and mesiolabially rotated in low-risk patients with mesially displaced canines (Tables II). Similar findings were previously reported by two radiographic studies, showing that maxillary lateral incisors crown adjacent to mesially displaced canines were 5° more mesially angulated (uprighted) and 11.7° more mesiolabially rotated, while the respective values obtained in this study were 9.3° and 8.8° (Table II).[17,43] It has been demonstrated that the mesial inclination of the maxillary permanent canine increases during the eruption process and reaches its highest value between 9 and 10 years of age.[7] This event is closely related to the peak of the “ugly duckling” stage, which is characterized by the distal angulation of the clinical crown of the maxillary lateral incisor and the mesial displacement of its root apex.[29,31,32] Considering that the root distal aspect of the maxillary lateral incisor works as a natural containment barrier for the canine's initial mesial and palatal movement, guiding its eruption,[43] a relevant reduction in distal angulation of the clinical crown of maxillary lateral incisors adjacent to displaced canines may be an important clinical sign that the canine has lost its relationship with its eruption guidance. In fact, the farther the canine sector was from its eruption guide (i.e. distal aspect of the lateral incisor root), the greater the lateral incisor mesial angulation, determining a significant positive correlation (Table III). A recent study showed that after early treatment of canine ectopic eruption, canines recovered their anatomical relationship with the distal aspect of the lateral incisor root, increasing the distal angulation of the maxillary lateral incisor crown towards an “ugly duckling” scenario.[17] Although the maxillary lateral incisor mesiolabial rotation has been associated with displaced canines,[43,57,58] its mechanism has never been described. However, it can be speculated that ectopic mesial displacement of the maxillary canine is closely associated with mesiolabial rotation of the maxillary lateral incisor, since lateral incisor rotation and canine displacement occurred in the same direction (mesial) and showed a significant correlation (Table III).[57]

Although a previous study found that palatally displaced canines were associated with palatal tipping of the maxillary lateral incisor,[43] this study did not confirm this result. The exclusion of anomalous maxillary lateral incisors may have contributed to this disagreement since maxillary lateral incisor anomalies were associated with Class II, Division 2,[59] which is known to have more palatally tipped incisors. The assumption that palatally displaced canine pushes the root apical third of the maxillary lateral incisor labially, displacing its crown palatally seems to be less likely to occur due to the greater bone volume to accommodate a palatal canine in this area. The inverse reasoning applied to the buccal displacement of canines seems to be more reasonable, since the buccal bone volume is very restricted in this site, causing palatal and mesial displacement of the lateral incisor root, as well as exaggerated distal angulation and proclination of its crown.[26,27,42]

The reason for excluding patients with dental anomalies, tooth size-arch length discrepancy, early loss of deciduous teeth, and sucking habits was that these genetic (lateral incisor anomalies[60]) and environmental (crowding and anterior transverse discrepancies[23]) risk factors are already well-known and easily recognized by clinicians as predictors of palatal and/or buccal canine displacement, suggesting the need for

radiographic investigation.[23,24] Unlike other studies,[40,43,61] the results showed high similarity in the mesiodistal, buccolingual, and cervico-occlusal dimensions of the maxillary lateral incisor between the patients with and without displaced canines (Table II). This fact suggests that the selection process was successful in excluding anomalous maxillary lateral incisors, which is a well-known risk factor for displaced canines.[3,24,41,60] In addition, this selection criterion may also have contributed to the similar morphological characteristic of the lateral incisor crown between the groups (Table II). Tooth size-arch length deficiency and transverse discrepancy, especially in the anterior segment of the dental arch, are well-known environmental risk factors associated with canine ectopic eruption.[5,23,27,52,56,62,63] Although the dental arch length was slightly shorter in the displaced canine group, the difference was supported by a borderline significance level (P=0.042, Table II). In addition, the similar anterior hemiarch perimeter between the groups suggests that the canine ectopic eruption in this study was not influenced by a relevant tooth crowding, which was excluded from this study. The transverse dimensions of the anterior and posterior maxillary dental arch were also similar for both arch width and hemiarch width, demonstrating that dental arch narrowing was not a significant environmental risk factor for canine displacement in this sample (Table II). It is known that the maxillary dental arch narrowing in the anterior segment is a significant predictor of canine ectopic eruption,[23,62] and that sucking habits lead to a reduction in maxillary arch width, particularly in the region of the canines.[64,65] Thus, the exclusion of patients with prolonged sucking habits was important to avoid the influence of this factor on canine displacement.

Although the panoramic radiograph does not allow a reliable ectopic canine location, especially when it lies in the apical zone,[25,66-68] the higher prevalence of palatally displaced canines raises the expectation that most canines in this study have moved in that direction.[25,69-73] A smaller palatal depth was observed in the displaced canine group (Table II). A similar finding was also reported in a previous study comparing patients with and without palatally displaced canines,[44] supporting the assumption that most canines were palatally displaced in the present study. Canines palatally displaced have been associated with a hypodivergent skeletal pattern,[3] which is likely to have a shallower and wider palate.[74] On the other hand, buccally displaced canines are more expected to occur in hyperdivergent patterns,[23] which have been associated with a deeper and narrower palate.[74]

The results showed that the canine ectopic position was more severe as the clinical crown of the maxillary lateral incisor was more mesially angulated and mesiolabially rotated, moving away from the normal features of the “ugly duckling” stage (Table III).[38,57] It has been shown that the severity of the canine ectopic position tends to increase with age.[8,38,57] Thus, a greater clinical visualization of these predictive parameters could be expected in older patients during late mixed dentition. Shallower palate and shorter dental arch length were also observed as the ectopic position of the maxillary canine became more severe, with arch length having the weakest correlation coefficient (Table III). Regression analysis showed that one-third of impaction cases can be predicted based on this regression model (Table IV). The mesiodistal angulation of the maxillary lateral incisors had the highest predictive power and alone was able to predict more than 20% of cases (Table IV). Findings from a previous CBCT study agree that the mesiodistal angulation of the maxillary lateral incisor was a significant factor in explaining the ectopic position severity of the maxillary canine.[38]

Clinical implications

The likelihood of low-risk patients developing ectopic maxillary canines should not be neglected. It has been successfully argued that genetic and guidance theories are complementary rather than two disconnected etiological hypotheses for canine ectopic eruption.[30,75] Some authors have advocated that patients who present maxillary lateral incisor anomalies or exaggerated distoangulation associated with proclination of the lateral incisor should be radiographically investigated.[24-26] The results of this study show that even low-risk patients, who do not have any known genetic and environmental risk factors, can present noticeable clinical signs that should be taken into account in clinicians' decisions about the need for a supplementary radiographic examination. Thus, patients with mesiodistally uprighted and mesiolabially rotated maxillary lateral incisors, contrary to the "ugly duckling" stage, and with a tendency to shallow palate should be radiographically evaluated, especially in the case of female patients. The predictive accuracy of these findings may be even higher if other known clinical signs are taken into account, such as the absence of labial canine bulge in the deciduous canine apical region in early mixed dentition, as well as the absence of deciduous canine mobility in late mixed dentition and the presence of a palatal bulge.[26,27,42,58]

Conclusions:

The null hypothesis was rejected.

- Low-risk patients with potentially impacted canines had a more mesially angulated and mesiolabially rotated maxillary lateral incisor crown and a shallower palate.
- Ectopic canines were more prevalent in females and the unilateral event was more prevalent than bilateral.
- Maxillary lateral incisor angulation inconsistent with the "ugly duckling" stage was the most important predictor of canine ectopic eruption in low-risk patients, significantly contributing to its early diagnosis.
- Considering the potentially devastating sequels of canine impaction, a radiographic investigation should be performed if these clinical predictors are identified in low-risk patients.

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Legend to figures

Figure 1- Clinical crown positional and dimensional characteristics of the maxillary lateral incisor. **A-** Angulation. **B-** Inclination. **C-** Rotation. **D**- Mesiodistal width. **E-** Cervico-occlusal height. **F-** Buccolingual width.

Figure 2- Dimensional characteristics of the maxillary dental arch. **A-** Palatal depth. **B-** Anterior arch length and anterior hemiarch perimeter. **C-** transverse dimensions of the dental arch. **D-** transverse dimensions of the dental hemiarch.

Tables

Table I - Comparability between the study groups.

Variables	Displaced canine N=41		Normal canine N=60		P
	Mean	SD	Mean	SD	
Age (years)	9.46	0.78	9.30	0.94	0.359†
Canine sector	2.46	0.66	1.00	0.00	<0.001‡*
Sex (%)	M (21.95%)		M (46.67%)		0.009§*
	F (78.05%)		F (53.33%)		
Canine rated	Unilateral (63.33%)		Unilateral (0%)		<0.001§*
	Bilateral (36.67%)		Bilateral (100%)		
Hemiarch (%)	Right (53.66%)		Right (50.00%)		0.717§
	Left (46.34%)		Left (50.00%)		

† *t*-test
‡Mann-Whitney U Test
§Chi-square test
*Statistically significant at P<0.05

Table II – Comparison of the maxillary lateral incisor and dental arch characteristics.

Variables	**Displaced canine position N=41**		**Normal canine position N=60**		P
	Mean	SD	Mean	SD	
Lateral incisor – positional characteristics					
Angulation (º)	100.69	10.20	91.35	7.98	<0.001†*
Inclination (º)	100.19	7.86	97.85	7.20	0.126†
Rotation (º)	45.06	13.38	53.85	11.64	<0.001‡*
Lateral incisor – dimensional characteristics					
M-D width (mm)	6.93	0.58	7.03	0.53	0.407†
C-O height (mm)	6.40	0.87	6.53	0.85	0.452†
B-L width (mm)	5.31	0.74	5.31	0.82	0.997‡
Lateral incisor – morphological characteristics					
Crown shape[a]	O (48.78%)		O (48.33%)		0.985§
	R (39.02%)		R (38.33%)		
	T (12.20%)		T (13.33%)		
Dental arch dimensions					
Palatal depth (mm)	12.00	1.88	13.18	1.64	<0.001‡*
Anterior arch length (mm)	12.70	1.73	13.54	2.03	0.042‡*
Intercanine width (mm)	32.95	2.35	33.29	2.33	0.482†
Intermolar width (D) (mm)	39.58	3.09	39.30	2.95	0.584‡
Intermolar width (E) (mm)	44.66	3.07	45.08	3.24	0.368‡
Intermolar width (6-6) (mm)	51.35	3.12	51.41	2.88	0.913†
Canine to sagittal plane (mm)	16.46	1.34	16.68	1.28	0.415†
Molar (D) to sagittal plane (mm)	19.85	1.51	19.63	1.61	0.317‡
Molar (E) to sagittal plane (mm)	22.37	1.60	22.54	1.76	0.922‡
Molar (6) to sagittal plane (mm)	25.64	1.71	25.67	1.64	0.926†
Anterior hemiarch perimeter (mm)	21.55	1.56	22.23	1.98	0.146‡

[a]R:rectangular; O, ovoid; T, triangular

† *t*-test

‡Mann-Whitney U Test

§Chi-square test

*Statistically significant at P<0.05

Table III - Relationship between the canine displacement severity and intergroup discriminant variables.

Variables (N=101)	**Canine sector**	
Lateral incisor	**R**	**P**
Angulation	0.45	<0.001*
Rotation	-0.30	0.002*
Palatal depth	-0.40	<0.001*
Anterior arch length	-0.21	0.035

*Statistically significant at P<0.05

Table IV – Stepwise multiple linear regression model used to predict ectopic eruption of maxillary canines.

Regression Model (N = 113)	**Beta coefficient**	**P**	**t**	**Partial R^2**	**R^2**
Angulation	0.43	<0.001*	5.15	0.21	0.33
Palatal depth	-0.27	0.001*	-3.27	0.09	
Sex	-0.17	0.046*	-2.01	0.03	

*Statistically significant at P<0.05

Figures

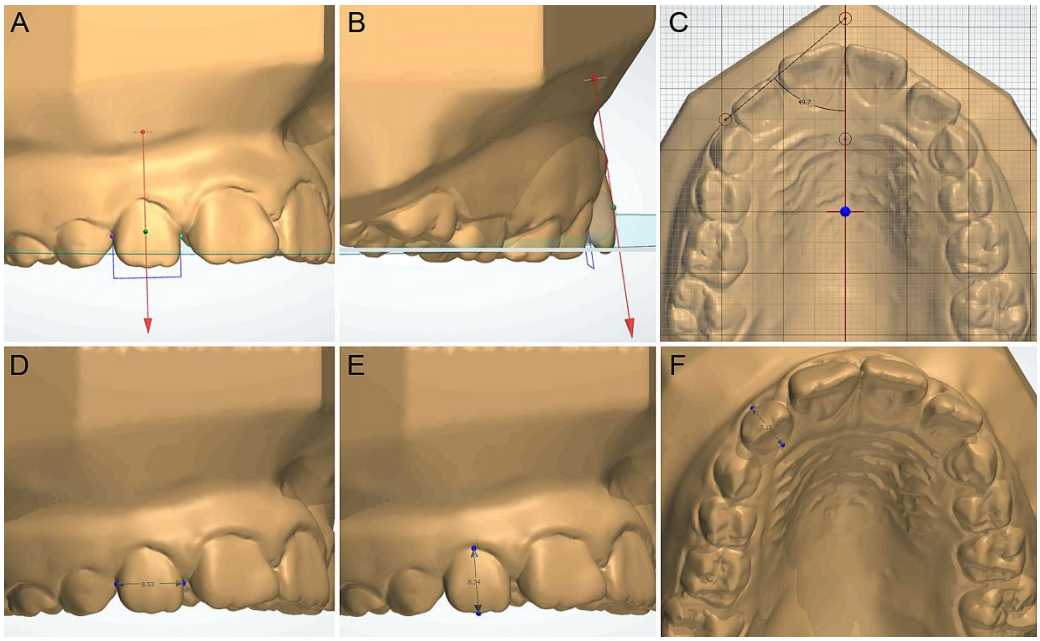

Fig1

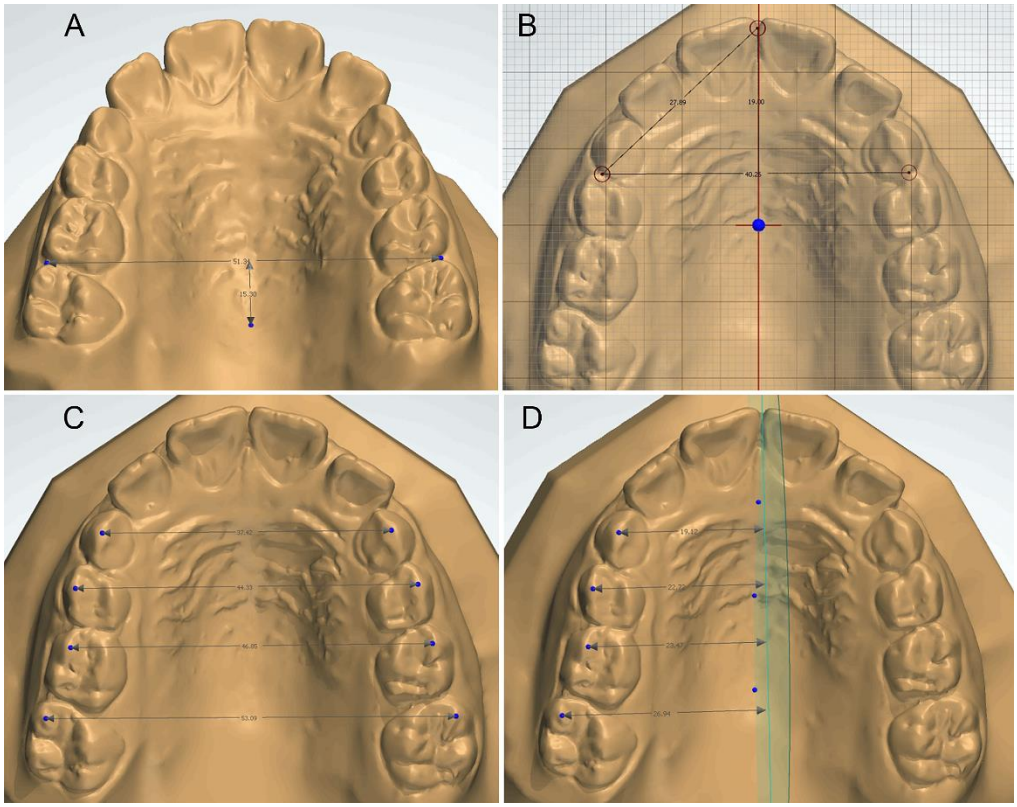

Fig 2

5 CONSIDERAÇÕES FINAIS

Com base neste estudo podemos concluir que pacientes de baixo risco com caninos potencialmente impactados apresentaram a coroa do incisivo lateral superior mais angulado mesialmente e com rotação para mesial assim como palato mais raso. A angulação dos incisivos laterais superiores inconsistente com a ‘fase do patinho feio’ foi o preditor clínico mais importante para erupção ectópica canina, contribuindo para o seu diagnóstico precoce. Considerando as sequelas potencialmente devastadoras da impacção canina a investigação radiográfica deve ser realizada na presença dos preditores clínicos descritos.

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