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Palatally impacted canines: A new 3-dimensional assessment of severity based on treatment objective

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Introduction: The severity of a palatally impacted canine (PIC) is gauged radiographically on 2-dimensional and 3-dimensional positional components: eg, angulation and height. We hypothesized that the position of a PIC relative to its virtual alignment in the arch is a better indication of impaction severity and treatment requirements. The aims of this research were to evaluate variations in PIC location on 3-dimensional images and to determine positional components associated with impaction severity. **Methods:** Linear and angular measurements of 38 PICs from 28 cone-beam computed tomography scans were made on the panoramic, coronal, sagittal, and axial sections. Measurements included angulation of the PIC to the virtually aligned canine, midline, and palatal plane; and distances between cusp tip and apex to various reference planes—eg, occlusal and midpalatal. Statistical assessments comprised *t* tests for group comparisons based on PIC and virtually aligned canine severity (cutoff at 30°) and Pearson product moment correlations for associations among variables. **Results:** Angulations of the PIC to the virtually aligned canine were 32.5° ± 15.5° (range, 9°-59°) and 19.6° ± 6.9° and 45.37° ± 9.6°, respectively, in the less severe and more severe groups ($P < 0.001$). Group differences were significant ($0.023 < P < 0.001$) for the apex and cusp distances between PICs and virtually aligned canines and to the midline reference planes, and for PIC angulations to the palatal plane and midline. Correlations were highest ($0.7 < r < 0.9$; $P < 0.001$) among PIC angulations to virtually aligned canines and to midline planes (panoramic and coronal sections), and cusp to midline distances (panoramic and axial views). **Conclusion:** A novel measurement of PIC inclination to its virtual aligned position indicates medial inclination of the most severe PIC with the crown farther from the alveolar crest and the apex more posterior. The crown varied over a wider range in the transverse plane; the apex varied over a comparatively narrower track anteroposteriorly. (Am J Orthod Dentofacial Orthop 2018;153:387-95)

The most frequently impacted teeth after the third molars are the maxillary canines (1%-3%), with most of them in a palatal position.[1] The variations in buccopalatal, vertical, and anteroposterior locations of impaction define treatment complexity and duration. Although severity of impaction and associated treatment difficulty are primarily ascribed to this 3-dimensional (3D) assessment, other critical factors include the applied surgical procedure (also associated with the tooth position), the amount and quality of the covering bone, and the traction mechanics including active force components and anchorage setup.

The various methods to determine impaction severity and relate it to treatment difficulty originated because of 2 major therapeutic side effects: the extended duration of orthodontic treatment[2-4] and the resorption of adjacent teeth, particularly lateral incisors, reported in nearly 50% of patients with a palatally impacted canine (PIC)[5,6] and related to unduly sustained forces in a protracted treatment.

Based mostly on 2-dimensional (2D) radiographs (periapical, intraocclusal, and panoramic), PIC severity has been stratified on positional components (horizontality, angulation, height). Ericson and Kurol[7] classified severity through cusp tip position in sectors drawn to the adjacent lateral and central incisors: impactions mesial to the lateral incisors are more severe than those

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in a more distal position. Stewart et al[4] associated severity and ensuing treatment time with the vertical distance of the cusp tip to the occlusal plane at a threshold of 14 mm. Pitt et al[8] determined that the canine's horizontal position, vertical height, buccopalatal position, and the patient's age projected severity and treatment difficulty. Crescini et al[9] found that every increase of 5° in the angle between the PIC and the midline resulted in 1 additional week of treatment. These approaches have not been compared in controlled studies and have not provided consistently predictable outcomes in patients. In addition, 2D radiographs cause variable distortions of anatomic dimensions and overestimated measurements, particularly patient positioning errors during radiography.[10,11]

Although concerns for excessive radiation initially limit the use of 3D imaging methods, including cone-beam computed tomography (CBCT), the risk is reduced by imaging the specific canine area. New indexes were developed to predict impaction potential. Kau et al[12] calculated a "KPG" index by adding the scores assigned to cusp tip and root tip in the 3 planes of space on the CBCT panoramic and axial sections. Alqerban et al[13] determined that the strongest predictors of impaction were the PIC's angulation to the lateral incisor, the distance to the occlusal plane, and the crown position relative to the arch and adjacent teeth.

The 3D methods have not yielded more definitively predictive information. Haney et al[14] determined that CBCT changed 2D-based diagnosis and treatment planning of impacted canines in 27% of the evaluations. Although occurring in a relatively low percentage, this difference may be critical for an individual patient and indicates the need to further explore variations of PICs in 3D imaging to improve the assessment of impaction severity and in the future its link with treatment outcomes.

In this article, we introduce a new scheme for severity assessment based on projected treatment outcome. Accurate determination dictated the reliance on 3D CBCT images. We hypothesized that the assessment of the PIC relative to its virtual posttreatment correction would better reflect the severity of impaction by personalizing the impaction to the patient. To this end, we defined the "virtually aligned canine" (VAC) as the simulated aligned tooth in its final posttreatment position in the arch to determine its position in all planes of space (Fig 1). Accordingly, the aim of this study was to determine, based on 3D images of PICs, the positional components associated with impaction severity in relation to treatment objective, not only diagnostic features. Treatment objective was defined as the simulated end position of the canine after treatment. See Supplemental Materials for a short video presentation about this study.

MATERIAL AND METHODS

Our material comprised CBCT scans of 28 patients (mean age, 16.06 ± 4.9 years; 16.9 ± 4.9 years for male subjects, 15.7 ± 4.9 years for female subjects) who had 38 PIC s (18 unilateral, 10 bilateral) and sought orthodontic treatment at the American University of Beirut Medical Center in Beirut, Lebanon. The scans were prescribed for accurate localization of the impacted canines after a clinical examination that included an initial diagnostic panoramic or periapical radiograph. This retrospective study was approved by the institutional review board.

CBCT scans were selected according to the following criteria.

1. Presence of unilateral or bilateral PIC. Canines had been considered at higher potential for impaction when they have not erupted into the oral cavity by the age of 13 years (1 year after the normal maxillary permanent canine eruption age range of 11-12 years[15]) and at the clinical examination, they were not palpable in the vestibule, prompting further radiographic confirmation. Within this scheme, 2 girls whose initial regional CBCT scans were taken at ages 10 and 11 were included in the study; they were treated nearly 1 year later with exposure of the canine and then with orthodontic traction into the arch. A subsequent preexposure CBCT scan was not taken to minimize radiation; the tooth was followed with periapical radiography.
2. CBCT scans of good quality and sufficient field of view covering at least half of the maxilla.

The exclusion criteria were craniofacial anomalies or syndromes and x-rays with limited field of view or low resolution that precluded accurate measurements.

Linear and angular measurements, recorded using the Ez3D Plus 3D CDViewer software (version 1.2.6.6; Vatech Global, Gyeonggi-do, Korea), included the following.

3. On the panoramic section (Fig 2), PIC/VAC angle, defined by the intersection of the axis of the impacted canine and the simulated aligned tooth between the adjacent teeth (lateral incisor and first premolar), determined by drawing a vertical line parallel to these teeth or along the long axis of the primary canine if present. Other measurements included the cusp tip to occlusal plane vertical distance, distances between cusp tip and apex to the midline, and the PIC angulation to the midline.
4. On the coronal section (Fig 3, *A*), the PIC angulation to the midline.