Association Between Canine Impaction and Skeletal Pattern in the Sagittal and Vertical Planes

In the present study, the authors evaluated the association of canine impaction with different skeletal discrepancies in two planes of space (sagittal and vertical). Cephalometric and orthopantomographic radiographic images of 45 patients with one or more impacted canines were used in this retrospective study. Five radiographic morphologic parameters—ANB angle, canine angulation, angle between the Frankfort horizontal plane and the mandibular plane (FH-MP), Wits appraisal analysis, and axial inclination of the maxillary incisors in the sagittal plane—were recorded for comparison. Statistical analysis was performed using SPSS 9.0 statistical package (IBM). Impaction of the maxillary canine was more frequent than mandibular canine impaction in both males and females, and palatal impaction was more common than buccal impaction, with a higher significance in males (64.7%) than in females (50%). In the sagittal relationship, the highest frequency of impacted canines was found in patients with a Class III skeletal discrepancy (44.4%), followed by Class I (28.9%) and Class II division 1 (15.6%), while the lowest frequency was in Class II division 2 (11.1%). Comparison between sexes in the vertical plane showed that impacted canines occurred more frequently in hyperdivergent female faces (51.1%) and hypodivergent male faces (48.9%). The result of this study indicates a statistically significant association of impaction with canine, sagittal, and/or vertical dentofacial discrepancies. The results also showed a higher risk of having impacted canines in patients with certain dentofacial deformities. Therefore, canine impaction may be used to represent a substitute scale for the study of different malocclusion groups with respect to race and ethnicity.


Canine impaction is the second major impaction (after third molar impaction1) and poses a challenge to both orthodontists and oral surgeons in treatment management and surgical approaches.2 Therefore, the dental literature has paid close attention to the physiology of canine eruption, as well as etiologic factors and the consequences of impaction. The diagnosis, treatment techniques, and alignment devices for impacted canines have been extensively studied, and their location in relation to the roots of adjacent teeth has been investigated.3 The definition of impaction varies among clinicians and the term has been used for palatally impacted canines, while labially impacted canines have been commonly defined as unerupted. The more current terms used are palatally and buccally displaced canines.4

Zahrani5 estimated that the incidence of maxillary canine impaction among the Saudi population was 3%, while Bishara6 found that among all individuals with impacted canines, 8% were bilateral and, interestingly, that unilateral impaction was five times more common than bilateral impaction. Moreover, Bishara found that maxillary canine impaction is 50 times more common than mandibular impaction, which is only about 0.35%.1,2 In addition, Bishara pointed out that palatal impaction is twice as
common in females than in males. This is consistent with Coulter and Richardson’s findings that maxillary canine impactions occur five times more often in Caucasians than in Asians, and that most canine impactions are palatal among Caucasians and buccal among Asians. Fournier et al reported a palatal-to-buccal impaction ratio of 3:1, while Jacoby reported a ratio as high as 12:1. Jacoby and Stellzig et al also reported arch length sufficiency in 82% of subjects with palatal impaction, while 85% of buccally unerupted canines were associated with crowding. Jacoby and Power and Short studied the location and angulation of the impacted canine as a predictive factor and established that if the tooth is angled more than 31 degrees to the midline, its possibility of eruption after deciduous extraction is decreased.

Surprisingly, none of the previously mentioned literature radiographically investigated the association between canine impaction and different skeletal deformities anteroposteriorly (Classes I, II, and III) and vertically (hyper- and hypodivergent). The aim of the present study was to radiographically investigate the association of canine impaction with sagittal and vertical skeletal discrepancies in Saudi subjects seeking orthodontic treatment. Sagittal discrepancies were assessed using Riedel’s ANB angle and Jacobson’s Wits appraisal. Vertical skeletal facial divergence was assessed using McNamara et al’s FH-MP angle.

Materials and Methods

Pretreatment radiographs ( panoramic radiographs and lateral cephalograms) of 45 subjects with one or more impacted canines were collected retrospectively from the files of the Orthodontics Department, College of Dentistry, King Saud University in Riyadh, Saudi Arabia. The sample consisted of 17 male patients and 28 female patients with a mean age of 16 years. Approval from the ethical committee of the College of Dentistry Research Centre was obtained (registration no. E-18-3297; IRB ref. no. 18/0572). All pretreatment panoramic radiographs were examined under an identical setting and traced on tracing paper with a 0.5-mm-diameter pencil for unilateral or bilateral canine impaction. Reference lines included the occlusal plane traced from the mesial cusp of the first maxillary molar on one side, touching the occlusal surface of most teeth of the same side, to the central incisor and ending at the midline; the same line was drawn on the other side. Another reference line used was the vertical midline that bisected the angle made by the long axes of the maxillary central incisors. If the central incisor roots were distinctly malpositioned and a vertical line passing from the intermaxillary suture was taken, then the axis of the impacted canine was drawn to bisect the vertical midline, and the angle between was measured to determine the location of the displaced canine. If the angle was > 31 degrees, the canine was considered buccally/ labially unerupted; if the angle was < 31 degrees, it was considered to be palatally impacted.

Skeletal sagittal and vertical discrepancy evaluations were performed on the lateral cephalograms. The ANB angle was used as the angular measure and the Wits appraisal as the linear measure to assess the sagittal relationship, while the Frankfort mandibular plane angle was measured to assess the vertical relationship. These measurements were traced and computed using the Dentofacial Planner Plus version 2.5b (Dentofacial Software).

Vertical Relationship

The angle between the Frankfort plane and the mandibular plane (FH-MP) was used to determine the vertical skeletal relationship by applying McNamara et al’s methods (Fig 1). If the vertical divergence was 31 degrees, it was classified as normo-divergent; if it was < 31 degrees, it was classified as hypodivergent; and if it was > 31 degrees, it was classified as hyperdivergent.

Sagittal Relationship

ANB Angle

Riedel suggested that the difference between the angles SNA and SNB (ANB angle) (Fig 1) could be used to classify the anteroposterior dental base relationship (Table 1). Therefore, to determine maxillary incisor protrusion or retrusion, the Downs method was applied in Class II cases only (to differentiate...
division 1 from division 2), measuring the distance between the incisal edge of the maxillary central incisor and the line from point A to the pogonion (Fig 2). If the distance was positive, it indicated the amount of maxillary dental protrusion, and if negative, it indicated incisal retraction. The mean was +2.7 mm, and ranged from −1 to +5 mm.

Wits Appraisal
According to Jacobson,15 Wits appraisal was defined as the distance between AO and BO, where AO and BO are points perpendicular to the functional occlusal plane from A and B, respectively (the occlusal plane being that line drawn through the maximum intercuspation of the first molar and premolars or deciduous molars, bisecting the maxillary and mandibular incisors anteriorly), as shown in Fig 3; the ANB angle was corrected by Eastman analysis.17 In the present study, a Class I skeletal relationship was determined when the AO-BO distance was −1.5 mm to −0.5 mm for male patients, and −0.5 mm to +0.5 mm for female patients. A large negative value indicated a Class III relationship and a large positive value indicated a Class II relationship (Table 1).

Table 1 ANB Angle Relationship and Wits Measurement

<table>
<thead>
<tr>
<th>Skeletal class</th>
<th>ANB angle, degrees</th>
<th>Wits, mm</th>
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<tbody>
<tr>
<td>I</td>
<td>2 to 4</td>
<td>−1.5 to −0.5</td>
</tr>
<tr>
<td>III</td>
<td>&lt; 2</td>
<td>&lt; −1.5</td>
</tr>
<tr>
<td>II</td>
<td>&gt; 4</td>
<td>&gt; −0.5</td>
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Statistical Analysis
Statistical analysis was performed with the SPSS 9.0 statistical package (IBM). Descriptive analysis and normal distributions were used to check the association between canine impaction and skeletal pattern and its variables (Table 2). P values < .05 were considered significant. Examiner reliability was assessed by replicating the measurement on 20
randomly selected panoramic and lateral cephalometric radiographs by two different examiners (inter- and intraexaminer reliability; H.O.A.B. and H.M.A.K.) 2 months after the first examination. These measurements were compared to the same measurements taken at baseline. The correlation coefficient between the two examiners was 0.95, which was very high and indicated a high degree of reliability.

**Results**

Canine impaction was most frequent in the maxilla (97.8%) in both sexes. Palatal impaction (55.6%) was more common than buccal impaction (44.4%), and this tendency was more significant in male than in female patients (Tables 3 and 4).

Canine impaction commonly occurred unilaterally, with right and left sides showing a similar frequency of occurrence (Table 4). Comparison of the sexes showed a higher incidence of unilateral buccal impaction in female patients, while male patients had a higher incidence of bilateral palatal impaction (Tables 3 and 4).

The results of this study also showed that patients with a Class III anteroposterior discrepancy are more prone to canine impaction than any other discrepancies (ANB angle: 33.4%; Wits appraisal: 44.4%), and this tendency was more pronounced in female patients (Table 5). The lowest incidence of canine impaction occurred in the Class II division II groups (ANB: 4.4%; Wits appraisal: 11.1%) (Table 5).
There were discrepancies between the ANB angle and the Wits appraisal in the classification of malocclusion of the same subjects. This was most marked when the ANB angle showed a high percentage of Class I malocclusions (33.2%), while the Wits appraisal showed a much smaller percentage (15.6%) (Table 5).

However, comparison of the vertical assessment between the sexes showed a higher frequency of hyperdivergence in female patients (57%) compared to male patients, who showed a higher frequency of hypodivergence (59%). Overall, there was a close correlation between canine impaction and hyperdivergence (51.1%).

### Discussion
A literature review revealed that the association between canine impaction and different skeletal discrepancies are an underinvestigated problem. Accordingly, the present study investigated this association radiographically in two skeletal planes (sagittal and vertical) for both sexes. Sagittal skeletal discrepancy was evaluated by combining angular and linear measurements to avoid the drawbacks of the methods recommended previously by Bishara et al.\textsuperscript{17} and Jacobson.\textsuperscript{18} In addition, the two groups were intentionally selected from one orthodontic practice, and traced by two examiners with no significant inter- and intraexaminer reliability errors. Bass,\textsuperscript{19} Thilander and Jakobsson,\textsuperscript{20} and Mossey et al.\textsuperscript{21} stated that women seek orthodontic treatment more often than men, which is confirmed in the sex distribution of the present sample.

Comparing this study with previous studies,\textsuperscript{10,22} the current findings were in agreement with those of Shroff,\textsuperscript{22} who noted that maxillary impaction (97.8%) is more common than mandibular impaction, and that palatal impaction (55.6%) is more frequent than buccal impaction (44.4%). However, Schindel and Duffy\textsuperscript{1} found a much higher incidence of palatal impaction (85%) than the present findings (55.6%). Additionally, Sukhia et al.\textsuperscript{23} and Mercuri et al.\textsuperscript{11} generally found a higher incidence of palatal impaction in both sexes (women: 67.4% palatal and 53.8% buccal; men: 65.8% palatal and 33.2% buccal). In the present Saudi sample, unilateral impaction was predominant in female patients, and the ratio of palatal canine impaction to buccal impaction was 2:1, which is in agreement with Gaulis and Joho,\textsuperscript{24} Peck et al.,\textsuperscript{25} and Mercuri et al.\textsuperscript{11} These proportions closely agree with the figures reported by Dachi and Howell,\textsuperscript{26} Bass,\textsuperscript{19} and Mossey et al.\textsuperscript{21}

Canine impaction occurred unilaterally in the current study, which closely agrees with Bass\textsuperscript{19} and Mossey et al.\textsuperscript{21} Bilateral impaction occurred less frequently than unilateral impaction, which agrees with Bishara’s finding.\textsuperscript{27} However, the present authors found that palatal bilateral impaction was more common in male patients, which disagrees with Bishara\textsuperscript{27} and Coulter and Richardson,\textsuperscript{7} who showed conflicting findings with no specification for buccal or palatal impaction type, while Sukhia et al.\textsuperscript{23} found that men had a higher incidence of buccal canine impaction and women had a higher incidence of palatal canine impaction.

Reports stated that due to a fundamental lack of certainty in angular methods of assessment, many other linear measurements have been proposed for determining the actual AP relationship of the arches.
Accordingly, the most common cephalometric tools are a combination of ANB angle and the Wits appraisal, used for assessing AP jaw discrepancies, which are used to diagnose skeletal discrepancies and address treatment strategies.

The present study had similar outcome and supports the finding of Basdra et al, who found that Class III subjects had a significantly higher rate of canine impaction (9%) than Class II division 1 subjects (1.33%), while in the present study both ANB angle and Wits appraisal yielded the lowest values in Class II patients. These findings both conflict with those of Al-Nimri and Gherabeh, Bass, Mossey et al, Basdra et al, and Jain et al, who reported a higher frequency of Class II division 2 malocclusions. The higher frequency of canine impaction associated with these malocclusions in their findings could be caused by smaller mandibles and retroclined incisors.

Discrepancies were noted between ANB angle and Wits appraisal measurement in the present study, where the ANB angle finding agrees with the findings of Boyd and Sukhia et al, who noted that most patients with impacted canines have an Angle Class I occlusion with varying degrees of crowding or spacing; the second finding agrees with Luffingham and Campbell, who reported a higher incidence of canine impaction in Class II division 1 malocclusions. The first finding could be attributed to the fact that canine impaction cannot be detected until it fails to erupt, while the second finding could be caused by smaller mandibles among the population.

Results from vertical skeletal assessment of subjects in the present study disagree with Sacerdoti and Baccetti, who found a higher rate of hypodivergent vertical skeletal relationships (62.2%) in subjects with palatally impacted canines. In addition, Amini et al’s findings were similar to those of Sacerdoti and Baccetti, suggesting that the vertical dimension might be smaller in patients with palatally displaced canines. This could be explained by the fact that their population had more Class II malocclusions and reduced vertical height. The present study’s higher canine impaction rate in hypodivergent male patients and hyperdivergent female patients could be related to the fact that even Saudis with balanced faces, as noted in previous studies by Talic and Al-Barakati, have a greater lower facial height than North Americans and Europeans.

Impaction was more frequently found in the maxilla than in the mandible. Palatal impaction was more common than buccal impaction, especially in male patients. Unilateral impaction was more significant in female patients, while bilateral impaction was more significant in male patients. Similarities between the ANB angle and the Wits appraisal were found in Class III malocclusions, with higher values found in female patients, and the lowest values found in Class II division 2 malocclusions. Discrepancies between the ANB angle and the Wits appraisal were found in Class I malocclusions (ANB angle was higher) and in Class II division 1 malocclusions (Wits measurement was higher).

Conclusions

The results of the present study suggest that skeletal discrepancy may influence canine impaction or vice versa, but the sample size should be increased to involve different governmental and private sectors from different geographic regions within the Kingdom of Saudi Arabia. The authors of the present study also found that canine impaction is also mostly associated with skeletal Class III patients, and therefore any delay in canine developmental eruption should be taken seriously and observed closely.

Acknowledgments

The authors would like to thank Mr Naser El Meflehi, college biostatistician, for his assistance. The authors are grateful to the deanship of Scientific Research, King Saud University for funding through Vice Deanship of Scientific Research Chairs. The authors declare no conflicts of interest.

References


