Local factors relating to mandibular canine impaction: A retrospective study

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Introduction: This study aimed to investigate the characteristics of impacted and transmigrated mandibular canines and the association existing between them and some local factors, such as degrees of axial inclination of mandibular incisors, skeletal Class, and mandibular symphysis width. **Methods:** A retrospective observational study was performed on the medical records and radiographic examination (panoramic radiographs and lateral cephalograms) of 102 orthodontic patients divided into a study group, with at least 1 impacted mandibular canine (51 subjects) and a control group, without mandibular impaction (51 subjects). A chi-square test, *t* test, and analysis of variance test analysis were used to analyze the data. **Results:** Unilateral and buccal impaction and the presence of the deciduous canine were the more prevalent characteristics of impacted canines, whereas 39.2% presented transmigration. Furthermore, the persistence of the deciduous canine on the impaction side ($P < 0.0001$) and the mesial axial inclination of the impacted canine ($P < 0.0001$) were found to be statistically significant characteristics. A statistically significant association was found between the impaction of the mandibular canine and mandibular incisor to the mandibular plane angle (IMPA) (IMPA, 95.8°; $P = 0.009$). An additional statistically significant association was found with transmigrated canines (IMPA, 96.8°; $P = 0.024$). **Conclusions:** The mesialization of the canine cusp and the persistence of the mandibular deciduous canine are characteristics frequently found in the impaction of the mandibular canine. An accentuated vestibular inclination of the mandibular incisors is significantly associated with mandibular canine impaction. (Am J Orthod Dentofacial Orthop 2024;■:■-■)

A tooth is defined as impacted when it has exhausted its eruptive thrust and remains within the bone structure without making its appearance in the arch during the physiological eruption time. It has a closed root apex with an inactive periodontal ligament.[1] The term retention, instead, refers to an intraosseous tooth that still has an immature apex and the possibility of finishing its eruptive course that it could not complete in the physiological period because of an obstacle or impediment.[2] An impacted or retained tooth rarely migrates away from the site in which it developed; however, if it does, it usually remains on the same side of the dental arch.[3] When the tooth crosses the midline, this phenomenon is known as transmigration.[4-6] The term was first used by Ando et al,[7] in reference to mandibular canines. Although most of the studies on transmigration concern mandibular canines, there are also instances reported in the literature of the transmigration of maxillary canines, mandibular lateral incisors, and premolars.[8-11]

Permanent maxillary canine impaction appears to be one of the most frequently reported dental anomalies in the literature;[12] however, only a few studies exist concerning the impaction of the mandibular canine.[13] This phenomenon occurs most frequently in the maxilla, with a reported prevalence ranging 0.97%-7.10%[6,14-19] compared with the mandibular site, which has a prevalence between 0.3% and 2.8%.[20-23]

Furthermore, the prevalence rate of transmigration ranges 0.10%-0.31%.[24]

There is no consensus in the current literature on the distribution and prevalence of a particular gender associated with mandibular canine impaction. In some studies, it was found to be more prevalent in females (F) (1.00 F to 0.35 male [M])[25] in others, such as those of Aydin et al[6] (1.00 M to 0.33 F) and Buyukkurt et al[26] (1.00 M to 0.67 F), it was found to be more common in M. It has been reported that the impaction of the mandibular canines predominantly affects the buccal site and the right side of the mandible.[6]

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Many general and local etiologic factors could cause impaction, altering the normal process of formation and eruption of the canine or deviating the tooth from its normal eruptive course. They are classified into general and local factors, and sometimes, several causes can occur in combination to determine the pathology.[27,28]

Although there are several theories in the literature about the etiology of mandibular canine impaction, and a genetic hypothesis has been formulated,[29] local factors are believed to be the main cause.[5,13,29-31]

Particularly, it has been suggested that the greater cross-sectional area of the anterior mandible compared with that of the maxilla,[6] excessive proclination of the mandibular incisor,[32] increased axial inclination, widening of the symphysis cross-section,[31] and skeletal Class II malocclusion, in particular with retroclined maxillary incisors,[33] which may offer favorable conditions for mandibular canine impaction.

Impacted mandibular canines usually remain impacted and asymptomatic; however, they can erupt ectopically on the same side or the opposite side of the arch, crossing the midline.[34] They may cause the resorption of roots or the tilting of adjacent teeth[35] and neurologic symptoms,[36] thus causing pain and discomfort to the patient. In addition to these mechanical complications, phlogistic or dysplastic complications may occur, such as follicular cysts and odontogenic neoformations, which may also be the effective cause of impaction.[22]

Regarding the transmigration of the mandibular canine (TMC), the etiology is still unknown; one of the theories is related to atypical lamina tissue drift and displacement of the tooth bud during the embryogenesis phase.[37,38]

Although there are several possible etiologic factors associated with responsible tooth impaction, this study focused only on some possible dentoskeletal factors, easily noticeable by basic radiographic examinations such as panoramic radiographs and lateral cephalograms, with the aim of evaluating a possible association that could be useful for the early interception of possible risk situations of mandibular canines impaction.

This retrospective, observational study of panoramic radiographs and lateral cephalograms aimed to investigate characteristics of impacted mandibular canines and TMC and assess whether an increased proclination of the mandibular incisors, the presence of a skeletal Class II relationship and a wide symphysis are more frequently associated with impaction of the canine in the mandibular arch.

MATERIAL AND METHODS

A retrospective, observational study was performed on the basis of information from clinical and radiographic findings (panoramic radiographs and lateral cephalogram) of patients treated at the Orthodontic Unit of the Department of Odontostomatological and Maxillofacial Sciences, Sapienza - University of Rome, Italy.

A total of 2507 medical records were analyzed (ie, those of all patients who were being treated within the Orthodontics Unit in 2022). The analysis of the pretreatment records of 2507 white patients was performed after the approval of the regional ethical review board of the "Umberto I" General Hospital of Rome (Rif. 3755).

Criteria for inclusion in the study sample were complete anamnestic information (concerning the subject's generalities, medical history, and orthodontic and dental treatment), with a good quality panoramic radiograph and lateral cephalogram.

Exclusion criteria were the presence of craniofacial anomalies or syndromes, systemic pathologies, ongoing radiotherapy or chemotherapy, head and neck surgery, and previous surgical-orthodontic procedures. Subjects with radiographs that could not be clearly analyzed were likewise not included.

The study group (SG) was represented by subjects with at least 1 mandibular-impacted canine without preference for depth, position, inclination, or location. The diagnosis was made on the basis of the clinical examination and available radiographic examinations (including 3-dimensional [3D] options in which available). The definition developed by Joshi et al[5] was used to diagnose transmigration, which assesses the tendency of the canine to cross the midline.

Of the 2507 subjects analyzed, 60 exhibited impaction of at least 1 of the 2 mandibular canines. Of these, 5 subjects were excluded because they did not have a lateral cephalogram, $\geq$3 more subjects were eliminated because they did not have a clear panoramic radiograph, 1 subject with a craniofacial syndrome, and a further subject who had undergone maxillofacial surgery were also excluded.

After this analysis, 51 subjects with at least 1 impacted mandibular canine who met the inclusion criteria were selected as SG.

The control group (CG) consisted of an equal number of patients from the Orthodontic Unit who did not have a mandibular canine impact, who showed similar characteristics in terms of age and presented complete medical records in the anamnestic information section and whose clear and traceable radiographs were available.

Two orthodontists (R.G. and F.G.) collected all the data and separately examined panoramic radiographs and lateral cephalograms on the subjects of both groups.

The data recorded included: (1) The subject's personal and medical history—gender, age, systemic

diseases, allergies, surgery, and trauma; (2) clinical and radiographic information—impaction and transmigration of mandibular canines, impaction side (right, left), the persistence of deciduous canine (presence or absence), cusp inclination of impacted canine (mesial, distal, or vertical, horizontal), impaction site (buccal, lingual, or in crest), skeletal classification (ANB), incisor mandibular plane angle (IMPA), and width (W) of mandibular symphysis (narrow, normal, or wide).

The impaction and transmigration of mandibular canines, impaction side, the persistence of the deciduous canine, and the cusp inclination of the impacted canine using the method by Bertl et al,[22] were evaluated on panoramic radiographs (Fig 1). The impaction site, skeletal Class, vestibular inclination of mandibular incisors, and symphysis anatomy were evaluated on lateral cephalograms (Fig 2).

All data were subsequently entered into Microsoft Excel (Microsoft Corp, Redmond, Tex). All panoramic and lateral cephalograms were acquired as jpg files. The panoramic radiographs were analyzed using a RadiAnt DICOM viewer (Medixant, Poznan, Poland) software.

On the lateral cephalogram, a cephalometric analysis was performed according to McLaughlin's method[39] using the Dolphin Imaging software (Dolphin Imaging and Management Solutions, Chatsworth, Calif).

The skeletal Class was calculated in the cephalometric analysis on the basis of the angle ANB, formed by the intersection at point N (nasion) of the straight lines passing through points A (maxillary) and B (mandibular): Class I: 2°-4°; Class II: >4°; and Class III: <2°

Tweed measurements were used to evaluate the sagittal variations of the incisor in the mandible.[40]

The value of IMPA is given by the angle between the long axis of the most protruding mandibular incisor and the base of the mandible (line joining the point [Me] and the "lower portion on the back of the mandible base"). The normal value of inclination of the mandibular incisors in relation to the mandible of the white ethnic group is 90° ± 5°.

The anatomy of the symphysis was classified according to the study by Gütermann et al[41] and Mazurova et al.[42] The W of the symphysis was calculated as the distance between the anterior and posterior line tangents to the symphysis perpendicular to the mandibular plane (a line tangent to the lower edge of the mandible) (Fig. 3).

The anatomy of the symphysis was classified on the basis of W as follows: (1) narrow symphysis: 14-15 mm; (2) normal symphysis: 15-16 mm; and (3) wide symphysis: ≥16 mm.

Statistical analysis

Statistical analyses were conducted with the SPSS program (version 25.0: IBM, Armonk, NY). The sample size was established after a power analysis was performed with the G*Power (version 3.1.9.7; Franz Faul, Universität Kiel, Kiel, Germany),[43] which showed that the minimum number of subjects to be included in the analysis was 88 (power = 0.80; $\alpha = 0.05$; effect size = 0.30).

To verify the reliability of the radiographic analysis and data collected by the 2 operators (R.G. and F.G.), all measurements were subjected to 2 separate random evaluations in 2 different periods. Cohen's κ statistic was conducted; the test result, on all measures considered, showed substantial interexaminer agreement between the 2 operators ($\alpha = 80$).

In addition, the same statistic was also used to assess intraoperator agreement 3 weeks after the first observations (κ >0.80).

The relative frequencies and, when possible, descriptive statistics (mean ± standard deviation) were calculated for all the variables under consideration. The chi-square and Fisher exact tests were used to assess possible associations between the impaction of mandibular canines and the variables considered.

This analysis was carried out both on the SG alone and in a comparison between SG and CG.

T tests for independent samples and analysis of variance were used to investigate the presence of significant differences in mean IMPA scores between the SG and CG (Student *t* test) and between subjects with transmigrated or nontransmigrated and CG (analysis of variance), respectively. The results were considered significant at a probability $P < 0.05$.

RESULTS

The study was carried out on a total of 102 subjects, 51 M (50.0%) and 51 F (50.0%), of whom 51 (50.0%) were in the SG and 51 (50.0%) in the CG. Specifically, in the SG, there were 28 M (54.9%) and 23 F (45.1%), whereas in the CG, there were 23 M (45.1%) and 28 F (54.9%).

The mean age of the participants was 14.8 ± 5.05 years: in the SG, the mean age was 14.7 ± 5.12 years (range, 10-33 years), whereas in the CG, the mean age was 14.9 ± 4.98 years (range, 10-31 years).

Of the 51 subjects in the SG, 56 impacted mandibular canines were analyzed. Five subjects (9.8%) had bilateral impaction, and the remaining 46 (90.2%) were unilateral. The chi-square test showed this result to be

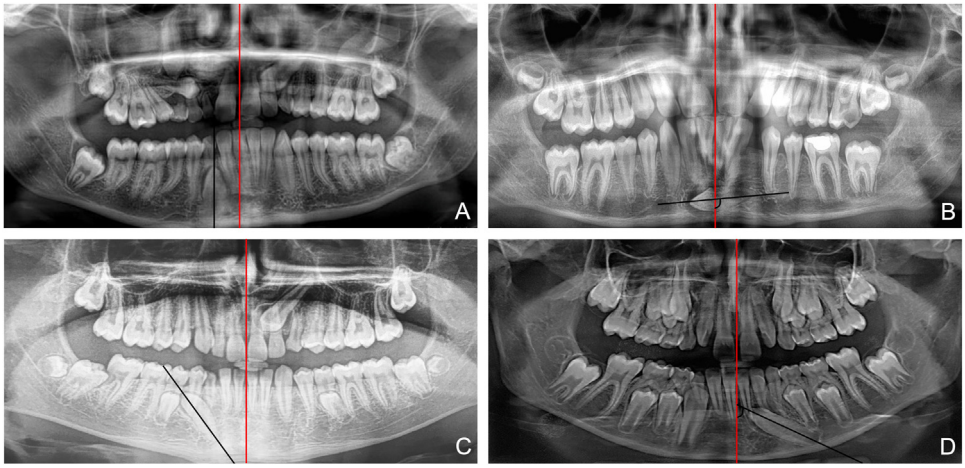

Fig 1. Using methods from Bertl et al,[22] the angle subtended by the line passing through the mandibular midline (*red*) and the line passing through the long axis of the mandibular canine (*black*) were traced to classified cusp inclination. **A,** 0° Classified as vertical coronally directed angulation; **B,** 90° As horizontal, mesially directed angulation; **C,** Negative values a distally directed angulation; **D,** Between 0° and 90° mesial cusp angulation.

statistically significant ($\chi^2 = 23.143$; $P < 0.0001$), with unilateral impaction more frequent than bilateral impaction.

Twenty-nine mandibular canines (51.7%) exhibited left-sided impaction (tooth 3.3) and 27 (48.2%) right-sided impaction (tooth 4.3). However, the frequency of distribution in relation to the side of impaction was not statistically significant ($\chi^2 = 0.071$; $P = 0.789$).

Forty-six of 56 mandibular canines (82.1%) had a buccal impaction site; of the remaining canines, 9 (16.1%) were impacted in the lingual site and 1 (1.8%) in the crest. The chi-square test showed this result to be statistically significant ($\chi^2 = 100.321$; $P < 0.0001$). Thus, a buccal site is more frequent in subjects with mandibular canine impaction.

Among the 56 canines analyzed, 46 (82.1%) still had the deciduous canine in the arch. The chi-square test revealed that the presence of the deciduous canine in the mandibular canine impaction side was statistically significantly more frequent ($\chi^2 = 23.143$; $P < 0.0001$).

Furthermore, 74.5% (38 of 51) of the subjects in the SG presented the impacted canines with a mesial cusp inclination, 5.88% (3 of 51) were oriented distally, 11.8% (6 of 51) had a vertical position, and 7.8% (4 of 51) were horizontal. The chi-square test showed this result to be statistically significant ($\chi^2 = 80.429$; $P < 0.0001$). Thus, in subjects with mandibular canine impaction, mesioangulation of the cusp is more frequent than in other orientations. In subjects with bilateral impaction, the same cusp angulation of the 2 elements was found. Results of the descriptive analysis of SG are synthesized in Table I.

In the SG, 20 of 51 (39.2%) patients presented transmigration. Nine of the 20 subjects (45.0%) were M and 11 (55.0%) were F.

In addition, of the 20 subjects, 11 (55.0%) had left-sided impaction, and the remaining 9 (45.0%) had right-sided impaction. This frequency distribution was not statistically significant ($\chi^2 = 3.700$; $P = 0.157$).

Three subjects had bilateral impaction, consisting of 1 transmigrated canine and 1 nontransmigrated canine. The chi-square test showed that, even with transmigrated canines, unilateral impaction is more frequent than bilateral impaction, and this distribution was statistically significant ($\chi^2 = 9.800$; $P = 0.002$).

All transmigrated mandibular canines occurred in the buccal site ($\chi^2 = 16.300$; $P < 0.0001$).

The chi-square test showed a statistically significant association ($\chi^2 = 12.800$; $P < 0.0001$) between TMC and the presence of the respective deciduous canine. The persistence of the mandibular canine in the arch was found in 18 subjects (90.0%).

Concerning the cusp inclination of the transmigrated canines, 16 subjects (80.0%) had a mesial angulation, and 4 (20.0%) had a horizontal angulation. No subjects had a distal or vertical cusp angle. This difference in frequency distribution was significant in the chi-square test ($\chi^2 = 7.200$; $P = 0.007$), underlining the tendency of transmigrated canines to have mesial cusp angulation.

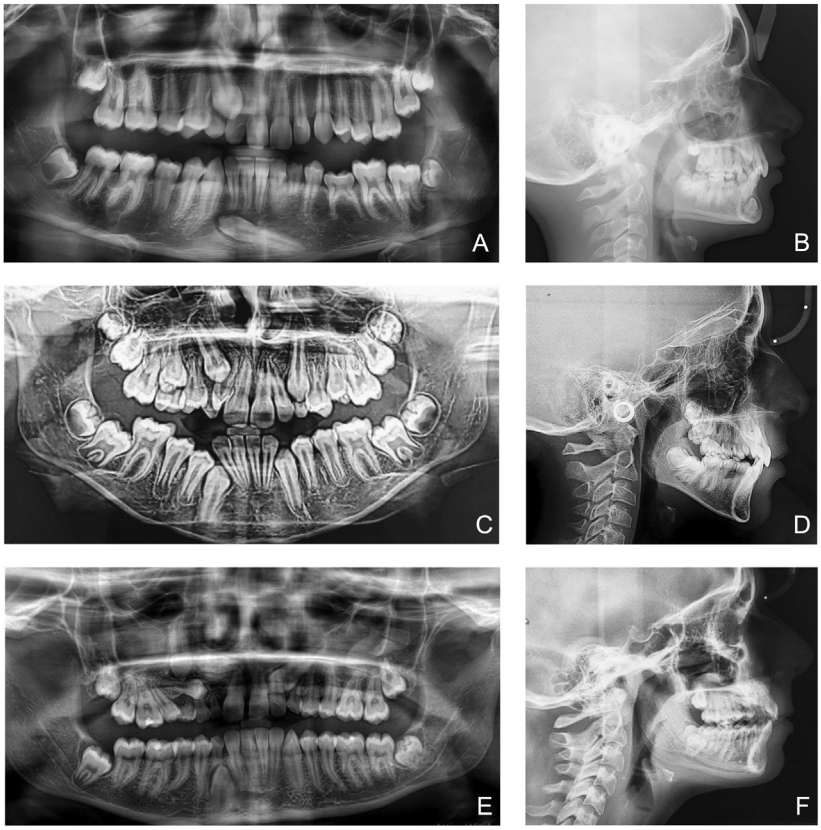

Fig 2. The impaction site described on the basis of the inclination analyzed on the lateral cephalogram and characteristics related to the case analyzed on panoramic radiographs. Patient 1: **A,** Panoramic radiograph showing the transmigration of mandibular left canine; **B,** Lateral cephalogram showing a buccal impaction. Patient 2: **C,** Panoramic radiograph showing an impaction of mandibular right canine without the persistence of deciduous canine; **D,** Lateral cephalogram showing a crest impaction of mandibular right canine. Patient 3: **E,** Panoramic radiograph showing an impaction of mandibular right canine with the persistence of deciduous canine; **F,** Lateral cephalogram showing a lingual site impaction of mandibular right canine.

Results for TMC are summarized in Table II.

In terms of gender, the chi-square test found no significant differences in the distribution of M and F within the 2 groups examined (28 M [54.9%] and 23 F [45.1%] in the SG and 23 M [45.1%] and 28 F [54.9%] in the CG) ($\chi^2 = 0.980$; $P = 0.428$).

The results of the t test made it possible to observe that the 2 groups considered had no significant differences with regard to age ($t = -0.183$; $P = 0.853$).

The results of the chi-square test showed that there is no significant association between belonging to the SG and CG and skeletal Class ($\chi^2 = 1.974$; $P = 0.373$). However, from the clinical point of view, the presence of subjects with a Class I relationship is more frequent in SG vs CG (26 of 51 [50.9%] vs 20 of 51 [39.2%], respectively). In contrast, subjects with a Class II relationship were less frequent in SG vs in CG: 43.1% (22 of 51) vs 49.0% (25 of 51), respectively. There were 3 subjects in SG (5.9%) and 6 in CG (11.7%) with a Class III relationship.

No significant associations emerged between SG and symphysis anatomy ($\chi^2 = 4.943$; $P = 0.084$). Thus, symphysis morphology was similar between SG and CG. In the SG, there were 19 subjects (37.3%) with normal, 16 with narrow (31.4%), and 16 with wide (31.4%) anatomy, whereas in CG, there were 27 subjects (52.9%) with normal, 7 (13.7%) with narrow, and 17 (33.3%) with wide anatomy.

There was no statistically significant association between subjects with elevated IMPA and symphysis anatomy ($F = 0.740$; $P = 0.392$).

Results comparing SG and CG are summarized in Table III.

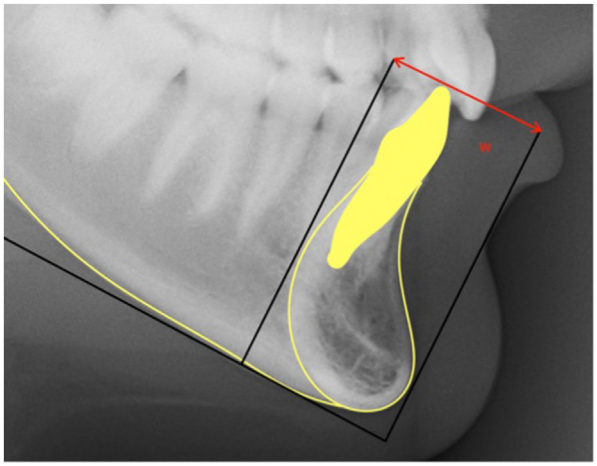

Fig 3. The W of the symphysis is calculated as the distance between the 2 lines tangents to the anterior and posterior point of the symphysis perpendicular to the mandibular plane (a line tangent to the lower edge of the mandible).

Table I. Descriptive statistics within the SG and results regarding characteristics of subjects and impacted mandibular canines

Variables	*n (%)*	χ^2	P *value*
Impaction side			
Unilateral	46 (90.2)	23.143	<0.0001
Bilateral	5 (9.8)		
Right	27 (48.2)	0.071	0.789
Left	29 (51.7)		
Impaction site			
Buccal	46 (82.1)	100.321	<0.0001
Lingual	9 (16.1)		
In crest	1 (1.8)		
Deciduous canine			
Presence	46 (82.1)	23.143	<0.0001
Absence	10 (17.8)		
Cusp inclination			
Mesial	38 (74.5)	80.429	<0.0001
Distal	3 (5.9)		
Vertical	6 (11.8)		
Horizontal	4 (7.8)		

Note. There were 51 subjects and 56 impacted canines in SG. Data were analyzed using the χ^2 test (Significance P <0.05).

The results of the *t* test revealed that the 2 groups had significant differences in terms of the value of IMPA (t = 2.656; P = 0.009). The average IMPA in SG was 95.8°, whereas it was 92.3° in the CG. The average IMPA in subjects with transmigrated mandibular canines was 96.8°, which was higher than that in the rest of the sample and statistically significant (F = 3.863; P = 0.024).

Analysis of variance and t tests (Table IV) were used to compare IMPA values in different groups.

DISCUSSION

Impaction of the permanent mandibular canine is a rare dental anomaly, with a few studies available in the literature.

This study analyzed one of the largest samples of mandibular canine impaction in the literature, with the aim of evaluating specific characteristics obtained from routine 2-dimensional radiographs (panoramic radiographs and lateral cephalograms). Any associations found could not only inform the clinician of possible risk factors but also confirm or reject associations already investigated in the literature and give rise to further future studies.

Previously reported prevalence rates for impaction of the permanent mandibular canine ranged from 0.3%-2.8%,[20-22] whereas transmigration ranged from 0.10%-0.31%.[23,24] This study found a prevalence of mandibular canine impaction of 2.4% in the orthodontic population under review. This result is within the range of the highest percentages found in the literature.[13] The prevalence of transmigration, 0.8%, is also in line with that in previous studies.[44]

In previous studies, predominantly panoramic radiographs were examined,[17] with only a few recent studies employing 3D computed tomography methods.[22,45,46] In this study, both panoramic radiographs and lateral cephalograms were evaluated.

Considering the results of this study, the data from the descriptive analysis of the sample revealed that there is no statistically significant gender difference in subjects with mandibular canine impaction and transmigration. This result, in agreement with Azeem et al,[44] contrasts with studies that reported a M-to-F ratio of 1 F to 0.33 M[6] and 1 F to 0.67 M[26] and with studies that instead highlighted a prevalence of the F sex.[3,47] In contrast, the prevalence of the F sex regarding the impaction of the maxillary canine has been reported by most of the studies, a finding that points to a genetic origin of the anomaly.[48]

In this study, most mandibular-impacted canines occurred unilaterally without significant differences between the right and left sides. Other studies have reported that unilateral canines are more frequent than bilateral ones.[49] Recently, it was reported that mandibular canines on the left side are more often impacted than those on the right.[6,25]

With regard to the impaction site, in this study, the buccal site of impaction was the most common; this is

Table II. Descriptive statistics within the SG and results regarding characteristics of subjects and transmigrated mandibular canines

Variables	*n (%)*	χ^2	P *value*
Impaction side			
Unilateral	17 (85.0)	9.800	0.002
Bilateral	3 (15.0)		
Right	9 (45.0)	3.700	0.157
Left	11 (55.0)		
Impaction site			
Buccal	20 (100)	16.300	<0.0001
Lingual	–		
In crest	–		
Deciduous canine			
Presence	18 (90.0)	12.800	<0.0001
Absence	2 (10.0)		
Cusp inclination			
Mesial	16 (80.0)	7.200	0.007
Distal	–		
Vertical	–		
Horizontal	4 (20.0)		

Note. There were 20 subjects and 20 transmigrated canines in SG. Data were analyzed using the χ^2 test (significance $P < 0.05$).

Table III. Descriptive statistics and general and clinical information comparing SG and CG

Variables	*SG*	*CG*	*t*	P *value*
Mean age (y)	14.7	14.9	−0.183†	0.853
Gender				
Female	23 (45.1)	28 (54.9)	0.980‡	0.428
Male	28 (54.9)	28 (45.1)		
Skeletal Class				
I	26 (50.9)	20 (39.2)	1.974‡	0.373
II	22 (43.1)	25 (49.0)		
III	3 (5.9)	6 (11.7)		
Symphysis anatomy				
Normal	19 (37.7)	27 (52.9)	4.943‡	0.084
Narrow	16 (31.4)	7 (13.7)		
Wide	16 (31.4)	17 (33.3)		

†Data were analyzed using a Student *t* test (significance $P < 0.05$);
‡Data were analyzed using a χ^2 tests (significance $P < 0.05$).

Table IV. IMPA scores between the SG and CG (Student *t* test) and between subjects with transmigrated or nontransmigrated and CG (ANOVA)

Variables	*IMPA*	*t or F*	P *values*
Student *t* test			
SG	95.8° ± 7.858°	2.656	0.009
CG	92.3° ± 5.323°		
ANOVA			
SG			
Impacted canine	95.2° ± 6.993°	3.863	0.024
TMC	96.8° ± 8.420°		
CG	92.3° ± 5.323°		

ANOVA, analysis of variance.
Note: Values are mean ± standard deviation. Statistical significance: $P < 0.05$.

consistent with previously reported findings.[50] In this study, the incidence of buccal impaction was higher than that of lingual impaction, particularly with transmigrated mandibular canines that can migrate buccally to the roots of the incisors[51] along the path of least resistance[3,36] also as a consequence of the more buccal position of bud formation.[52]

The exact etiologic mechanism that causes canine impaction remains unclear, and several theories have been put forward to explain this phenomenon.[3] Early loss of primary teeth and the loss of the resulting space by adjacent teeth have been suggested by Azeem et al.[44] This hypothesis contrasts with these results, considering that, in this study, the primary canine was present in 82.1% of subjects. This is in agreement with the literature on the topic, which supports the association of mandibular canine impaction with the persistence of the homolateral deciduous canine over the physiological time of exfoliation.[50] The deviation of the succedaneous canine from the normal eruptive path slows down the resorption processes of the deciduous canine root.[5]

Other factors most frequently associated with the impaction of the mandibular canine, such as the IMPA, Class II malocclusion, and the enlargement of the symphyseal cross-sectional area were examined in this study. Only the IMPA value was found to be significantly increased in subjects with mandibular canine impaction. This finding is in agreement with studies in the literature, although there exist only case reports,[53] case series,[32] or small sample studies.[31] This study did not aim to evaluate whether incisor proclination is a cause or effect of mandibular canine impaction but to evaluate a possible association. Establishing an association between impaction and increased IMPA may be useful in any case, as it may indicate a possible risk factor that could be adequately evaluated in a study with radiographic controls over time. In addition, the use of 3D radiographs may, in the future, help to understand possible differences in subjects with unilateral impaction and different proclination of the mandibular incisors on the 2 sides.

Peck et al[29] and Plakwicz et al[50] considered that Class II Division 2 malocclusion could be a possible risk factor for impaction. However, in this study, the Class II malocclusion was present in equal measure between the 2 groups.

In contrast with the literature,[32] this study did not find any correlation between the impaction of the mandibular canine and the anatomy of the symphysis.

In this study, transmigration occurred in 39.2% of subjects with impacted mandibular canines. These elements showed a statistically significant higher mesial cusps inclination. This evidence is in agreement with the retrospective cross-sectional study of Bertl et al[22] who analyzed the computed tomography and/or cone-beam computed tomography data of 88 subjects with a total of 94 impacted mandibular canines. In this study, subjects with transmigrated mandibular canines are also positively associated with a higher increased IMPA value than that of subjects with impacted mandibular canines and the CG, as also reported by Vichi et al.[32]

It could be hypothesized that there is a higher probability of impaction and transmigration of mandibular canine in association with the persistence of the deciduous canine, the mesial tipping of the impacted canine cusps, and the increase of buccal inclination of mandibular incisors.

CONCLUSIONS

The mesialization of the canine cusp and the persistence of the mandibular deciduous canine are characteristics frequently found in patients with mandibular canine impaction. An increased IMPA is found to be significantly associated with this anomaly.

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AUTHOR CREDIT STATEMENT

Rosanna Guarnieri contributed to conceptualization, methodology, investigation, validation, data curation, manuscript review and editing, and visualization; Francesca Germanò; contributed to original draft preparation, software, formal analysis, and investigation; Giulia Sottile contributed to investigation and resources; Ersilia Barbato contributed to supervision and project administration; and Michele Cassetta contributed to conceptualization, validation, supervision, and project administration.

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