

Permanent mandibular canine(s) impaction: expansion of our understanding

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Introduction: Eruption disturbances, tooth size and specific malocclusions are known to be genetically influenced. The clinical association between these traits may indicate common genetic controls.

Objectives: A cross-sectional clinical study was designed to test the null hypothesis that the maximum mesiodistal crown diameter (MMD) of maxillary and mandibular central and lateral incisors and the prevalence of various classes of incisor relationships (Class I, II/1, II/2 and III) do not differ between the subjects with and without permanent mandibular canine(s) impaction.

Methods: Dental models of 43 subjects diagnosed with mandibular canine(s) impaction (Impaction Group - IG) were compared with those of 86 subjects of a control reference sample (Control Group - CG). Independent *t*-test and chi-square tests were used to determine the association between mandibular canine(s) impaction and the MMD of the incisors and the incisor relationship, respectively. The likelihood of various incisor relationships between the IG and CG were evaluated according to odds ratios.

Results: A fourfold increase ($p < 0.0001$) in the overall frequency of Class II/2 incisor relationship was observed in the IG when compared to controls.

Conclusions: The null hypothesis was rejected. Subjects with mandibular canine(s) impaction appeared to be characterised with wider incisors and a remarkably high rate of Class II/2 malocclusion. This information assists the understanding of genetically controlled dental anomalies, which are likely to co-exist with mandibular canine(s) impaction.

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Introduction

Appropriately referred to as the cornerstones of the dental arches, the 'permanent canines' are important structurally, functionally and aesthetically.¹ This is illustrated by the fact that these teeth are rarely found to be missing.² However, canines are prone to impaction, which is defined as a failure of tooth eruption caused by a physical obstacle or by the abnormal position of the tooth.³

Bluestone first described the impaction of permanent mandibular canine (PMC/s) which occurs approximately 20 times less frequently when

compared with that of the maxillary canine.^{4,5}

There is insufficient information in the orthodontic literature which describes the relationship of mandibular canine impaction with dental anomalies of other teeth, particularly anomalies related to tooth size and the sagittal occlusal relationship of the incisors.⁶ Peck cited the role of genetics in the aetiology of ectopic mandibular canines.⁷ Heredity is known to influence tooth size⁸ and plays a role in the occurrence of various malocclusions (Class I, II/1, II/2 and III).⁹ A possible association between PMC impaction and the size and relationship of the incisors, as represented

by the malocclusion category, is therefore likely and needs further investigation. A strategy to understand and clarify how the genetic code might affect biologic processes is through comparison and testing of carefully selected samples for significant occurrence differences in variables that have known genetic control mechanisms.¹⁰

Therefore, the present study aims to test the null hypothesis that the maximum mesiodistal crown diameter of maxillary and mandibular central and lateral incisors and the frequency of various classes of incisor relationship (Class I, II/1, II/2 and III) do not differ between subjects with and without permanent mandibular canine(s) impaction. Besides contributing to the dental literature on a rare, but orthodontically important anomaly, the results are expected to yield clinically useful information pertaining to the identification of risk factors, early diagnosis and eventual treatment planning of mandibular canine impaction.

Material and methods

Following the approval of the institutional review board, a cross-sectional clinical study was designed and undertaken at the Department of Orthodontics, Purvanchal Institute of Dental Sciences (PIDS) in Gorakhpur, India. The research was conducted in full and in strict accordance with ethical principles and including those from the 'Declaration of Helsinki (2008)'.

A multistage sampling technique was adopted to select subjects exhibiting PMC(s) impaction from various schools in the district Gorakhpur, Uttar Pradesh, India. The geographic map of the district was obtained and divided into six zones from which two schools were randomly selected. All students of at least 14 years of age, from the 12 schools, were evaluated and a total of 10,422 (females:males, 0.9:1) subjects were screened. Fifty-nine subjects fulfilled the selection criteria for the diagnosis of mandibular canine(s) impaction, according to the subject's history, clinical and radiographic examination (orthopantomograph, occlusal, intra-oral periapical views assessed using Clark's rule and Lateral cephalogram).¹¹ A mandibular canine was accepted as impacted only if it showed radiographic evidence of complete root formation.

The following factors led to the exclusion of 16 subjects: (1) factors relating to the clinical or

radiographic evidence of supernumerary teeth, odontoma or cyst; (2) factors directly related to the unerupted mandibular canine(s); (3) congenitally missing teeth, including mandibular canine(s) but excluding third molars; (4) a history of trauma or extraction of any primary or permanent tooth; (5) the presence of gross caries interproximally, orofacial clefts or any other hereditary, syndromic or systemic manifestations and previous endodontic treatment of primary mandibular canines, which possibly influenced the eruption of the permanent mandibular canine; (6) dissimilar dental¹¹ and skeletal¹² classification categories and (7) a history of prior orthodontic intervention and inadequate diagnostic records.

The IG of 43 subjects was Indian by origin and ranged between 14-21 years of age with a mean of 15.8 years. Maxillary and mandibular alginate impressions for each subject were taken and the dental models poured in plaster.

A CG, as a reference sample, consisted of study models from 86 age- and gender-matched Indian subjects, randomly selected from the initial subjects, but who had complete eruption of both PMCs.

Using the study models and a specially tipped electronic digital caliper (Digimatic caliper; Mitutoyo, Kawasaki, Japan), MMD was recorded in millimetres (to the nearest of 0.01 mm) for the permanent maxillary and mandibular central incisors (CI) and lateral incisors (LI) on both sides of each dental arch for all the subjects by a single investigator (SJ), who was blinded to the null hypothesis. The same investigator also assigned the incisor relationship on the models as either Class I, Class II/1 (Class II division 1), Class II/2 (Class II division 2) or Class III, based upon the relationship between the lower incisor edges and the cingulum plateau of the maxillary central incisors.⁶

Data consisting of age, gender, tooth sizes and incisor classification were collected and entered into a spreadsheet (Excel 2000, Microsoft Corporation, Redmond, WA, USA). Statistical analyses were performed using SPSS (version 17, Chicago, IL, USA).

Statistical analyses

Paired *t*-tests were used to compare the differences in MMD for each incisor type between affected and unaffected sides in subjects with unilateral PMC impaction and right versus left sides in those

with bilateral impactions. A comparison for MMD between the IG and CG was conducted using the independent two sample *t*-tests. A chi-square test assessed the difference in distribution of the various classes of incisor relationships between the groups. If a statistical significance was found, odds ratios (IG/CG) were evaluated as an approximation of the relative risk that PMC impaction held for each type of incisor relationship. Statistical significance was set at $p < 0.05$.

Two weeks later the same examiner (SJ) undertook duplicate measurements of MMD on all incisors and observations of the incisor relationship of 20 study models randomly selected from each group. A double determination method was used to compare the intra-examiner error or agreement in relevance to tooth size measurements.

Results

The distribution of subjects with PMC(s) impaction, stratified by location and gender, is summarised in Table I. Of the 43 subjects in the IG group, only 6 (14%) were affected bilaterally. Unilateral impaction occurred with similar frequency on the right (46%) and left (40%) sides. The incidence of females to males was in a ratio of 2.1:1.

The double determination method revealed that the mandibular left CI in the CG group revealed no discrepancy (0.000 mm), while the maxillary right LI in the IG group had a mild (0.003 mm) but statistically insignificant intra-examiner error of measurement. Reproducibility was 100% for incisor relationship.

As presented in Table II, paired *t*-tests showed no statistically significant differences in MMD between corresponding teeth on each side. This confirmed a strong metric agreement between homologous maxillary and mandibular CI and LI¹³ and allowed the pooling of data and the use of mean MMD of the right and left sides of each incisor type. Table III

reports descriptive statistics of MMD of the maxillary and mandibular CI and LI for the IG and CG groups. An independent two-sample *t*-test showed that three (maxillary LI, mandibular CI and LI) of four tooth types had statistically significant differences ($p < 0.05$) between the groups. In general, the MMD tended to increase in subjects displaying mandibular canine(s) impaction, when compared with controls, in the present study.

The occurrence rate of various incisor relationships showed significant differences between the IG and CG groups (Table IV, $p = 0.000$, chi-square test). The odds ratios, used for the evaluation of incisor relationship as a prospective risk factor for the IG/CG, are shown in Table V. The values above one (1.60 [$p = 0.23$] and 6.61 [$p < 0.0001$] for Class II/1 and II/2 respectively, only the latter being statistically significant) indicated the risk a particular incisor relationship carried for the frequency of impaction of mandibular canines.

Discussion

The documented incidence of PMC(s) impaction varies from 0.05% to 1.29%.^{5,14-17} Although it was not within the scope of the present study to refer to the epidemiology of the PMC(s) impaction, the differences in reported prevalence led to the investigation of its frequency. The incidence was found to be 0.41% in an Indian subpopulation sample of 10,422 school-age subjects. This differs from previous reports, likely due to racial factors, along with study design and sampling variations. A predilection for female prevalence observed in the present study was strikingly obvious compared with previous reports.¹⁵ However, observations on the location of canine impaction (right versus left and unilateral versus bilateral) closely paralleled previous reports.¹⁵ Since definite conclusions have not yet been extrapolated regarding the aetiology of labial and lingual mandibular canine(s) impaction, no attempts were made to isolate these for the purpose of this study.

Tooth size is a relevant investigative topic because it has a direct impact on orthodontic diagnosis, treatment planning, prognosis and retention.¹⁸ Forseberg¹⁹ indicated that most teeth are significantly wider mesiodistally, in cases involving impacted third molars, compared with cases of normally erupted molars. A similar trend was confirmed by the present study, in which three (maxillary LI, mandibular CI

Table I. Distribution of PMC(s) impaction cases according to location and gender.

Location/gender	Females	Males	Total
Bilateral	4	2	6 (14%)
Unilateral right	12	8	20 (46%)
Unilateral left	13	4	17 (40%)
Total	29 (67.44%)	14 (32.56%)	43 (100%)

Table II. MMD of maxillary and mandibular CI and LI, comparison between affected and unaffected sides in unilateral impaction subjects and between right and left sides in bilateral subjects.

Location/ MMD		Maxillary CI	Maxillary LI	Mandibular CI	Mandibular LI
Unilateral	Affected side	8.43 ± 0.63	6.56 ± .73	5.37 ± 0.43	5.91 ± 0.44
	Unaffected side	8.45 ± 0.59	6.59 ± 0.83	5.35 ± 0.37	5.91 ± 0.47
	<i>p</i>	0.856 [#]	0.895 [#]	0.858 [#]	0.988 [#]
Bilateral	Right	8.19 ± 0.46	6.9 ± 0.4	5.07 ± 0.54	5.72 ± 0.73
	Left	8.21 ± 0.36	6.98 ± 0.44	5.01 ± 0.47	5.8 ± 0.5
	<i>p</i>	0.683 [#]	0.751 [#]	0.842 [#]	0.830 [#]

CI, Central incisor; LI, lateral incisor; MMD, Maximum mesiodistal crown diameter; [#] Non significant ($p < 0.05$, statistically significant) paired *t*-test

Table III. Comparison of MMD of maxillary and mandibular CI and LI between the IG and CG groups.

Groups / MMD	Maxillary CI	Maxillary LI	Mandibular CI	Mandibular LI
IG	8.40 ± 0.45	6.63 ± 0.72	5.32 ± 0.41	5.89 ± 0.46
CG	8.39 ± 0.13	6.42 ± 0.13	4.89 ± 0.21	5.40 ± 0.13
<i>p</i>	0.711 [#]	0.012 [*]	0.000 ^{**}	0.000 ^{**}

IG, Impaction group; CG, Control group; CI, Central incisor; LI, lateral incisor; MMD, Maximum mesiodistal crown diameter; [#] Non significant; ^{*} $p < 0.05$, statistically significant; ^{**} $p < 0.001$ (statistically significant) independent two-sample *t*-test

Table IV. Distribution of various incisor relationships in the IG and CG groups.

Groups/classes of incisor relationship		Class I	Class II/1	Class II/2	Class III	<i>p</i>
IG	Number of subjects	6 (14%)	17 (39.5%)	20 (46.5%)	0 (0.0%)	0.000 ^{**}
						Chi-square = 29.70
CG	Number of subjects	44 (51.2%)	25 (29.1%)	10 (11.6%)	7 (8.1%)	Degree of freedom = 3

IG, Impaction group; CG, Control group; ^{**} $p < 0.001$ (statistically significant) Chi square test

Table V. Ratio of odds of various incisor relationships between the IG and CG groups.

Classes of incisor relationship	Odds ratio (IG/CG)	95% Confidence interval		z statistic	<i>p</i>
		Lower bound	Upper bound		
Class I	0.15	0.06	0.40	3.81	0.0001 ^{**}
Class II/1	1.60	0.74	3.44	1.20	0.23
Class II/2	6.61	2.71	16.11	4.15	< 0.0001 ^{**}
Class III	0.12	0.01	2.18	1.43	0.15

IG, Impaction group; CG, Control Group; ^{**} $p < 0.001$ (statistically significant)

and LI) incisors showed a statistically significant increase in MMD in the IG group in comparison with controls. This trend towards wider incisors is possibly indicative of a generalised increase in tooth size throughout the dentition.²⁰ When larger tooth size alterations contribute to a tooth-size, arch-length discrepancy, the result is crowding, proclination and/or perhaps impaction of one or more teeth. As lower canines normally erupt prior to the mandibular premolars,²¹ it is unlikely that wider than average incisors mechanically encroach upon the space available for the eruption of the remaining teeth and thereby, lead to the impaction of canines rather than premolars.

Furthermore, it is noteworthy that even though the investigation focused on the impaction of mandibular canines alone, the particular eruption anomaly is shown to be associated with incisor size alterations both in the maxilla as well as the mandible. From this perspective, it seems reasonable to assume that the association between incisor size alterations and mandibular canine(s) impaction may not be purely mechanical or causal but rather, non-causal and biologically or genetically related.²² This concept is validated by previous reports which are consistent with a growing body of evidence identifying a complex combination of genetically controlled dental disturbances.²³⁻²⁵ Taguchi et al. suggested that the eruption disturbance of the mandibular canine is most often caused by a disturbance of the canine germ itself, and in rare cases by space deficiency or a pathological event.²⁶ Of clinical interest is the trend towards wider than average incisors, as may be assessed in the early mixed dentition, especially in combination with other associated dental anomalies, could serve as a useful predictor of mandibular canine impaction.

Another trait, which can be easily identified in the early mixed dentition, is the sagittal occlusal relationship of the incisors. The present study showed significant differences in the incidence of various incisor relationships between the IG and the CG groups, with a fourfold statistically significant, more frequent occurrence of Class II/2 in the IG group. An odds ratio of 6.61 at the 95% confidence interval indicated a significantly strong connection between mandibular canine impaction with Class II/2 ($p < 0.0001$). Accordingly, it was considered that Class II/2 is a possible risk factor for mandibular canine(s) impaction. In addition, a Class II/2 malocclusion was proposed as a risk factor for palatal impaction

of maxillary permanent canines.²⁷ Mossey explained the occurrence of a Class II/2 malocclusion, based on the polygenic model with a simultaneous expression of numerous gene-controlled morphological traits acting additively.⁹ The early diagnosis of mandibular canine(s) impaction, particularly in association with a Class II/2 malocclusion, may therefore indicate an increased risk of other genetically-linked anomalies and help identify patients who might benefit from preventive or interceptive intervention.

Class II/2 malocclusion cases are known to be associated with small teeth.²⁸ This likely explains the statistically insignificant results related to the MMD of maxillary CI. This view is at variance with the results obtained with respect to maxillary LI and the mandibular CI and LI. The disagreement related to the maxillary LI exists because of its accepted variability in size.²⁹ Mandibular incisors seem to be relatively free from the reported influence of the Class II/2 malocclusion on tooth size.²⁸ The current study found that wider than average mandibular incisors were present in subjects with mandibular canine(s) impaction. An additional implication of the observed relationship between mandibular canine impaction and the incisor relationship is that the frequent incidence of a Class II/2 malocclusion (and Class II/1 malocclusion) in the IG group could make the patients aware at an earlier stage of development which could allow earlier identification of the problem.

Even though the number of subjects in the IG group reflects the probable representation of mandibular canine(s) impaction in the subpopulation studied, it may be argued that this number was insufficient for a meaningful interpretation of the data. A sample size of forty-three may be acceptable for a study investigating a relatively unusual anomaly⁵ of mandibular canine impaction and for a study which is the first to report the frequency of PMC(s) impaction in Indians. Furthermore, since tooth size alterations observed in the present study may be too small to be clinically acknowledged, the findings must be considered preliminary and further verification in a more extensive study with more elaborate resources is recommended. It shall be of great interest, in view of the present clinical results (association of mandibular canine impaction with tooth sizes and incisor relationship), to speculate and subsequently examine whether genes associated with mandibular canine eruption/impaction are also involved in determining the sizes of other teeth as well as affecting the incisor relationship.

Conclusions

When compared with control patients, cases exhibiting PMC(s) impaction revealed a trend towards wider incisors. A remarkably higher incidence of a Class II/2 incisor relationship was observed in subjects with mandibular canine(s) impaction compared with controls. Apart from helping clinicians to identify possible risk factors associated with mandibular canine impaction, tooth size information enhances understanding of the origin and development of the eruption anomaly and the possible mechanisms of examination and treatment.

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