Evaluation of the mandibular arch in patients with impacted permanent lower canines

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Aim: To determine the features of the mandibular dental arch in subjects presenting with impacted permanent lower canines.

Methods: The ‘impaction group’ consisted of 48 Indian subjects with mandibular canine impaction (Females:Males, 1.5:1; mean age, 15.03 ± 0.49 years). The ‘control group’ was comprised of 96 age-, gender- and malocclusion-matched Indians who were randomly selected from subjects initially screened but who had completely erupted mandibular canines. Arch width, arch length, arch shape and space status (total tooth size, arch-length – tooth-size discrepancy) were assessed using dental models and were compared between the groups using comparative measurements and statistics.

Results: Statistically significant differences were demonstrated with respect to the arch length, arch shape, total tooth size and arch-length – tooth-size discrepancy (p = 0.03, 0.02, 0.04, 0.01; independent 2-sample t-tests, respectively). Crowding was more prevalent in subjects with impaction than in the controls, with the difference being statistically significant (chi-square = 13.202; degrees of freedom (df) = 4; p = 0.010).

Conclusion: Patients with permanent mandibular canine impaction have adequately wide but shorter lower dental arch forms along with wider mandibular total tooth size and greater arch-length – tooth-size discrepancy when compared with a control sample.

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Introduction
The discovery of an impacted permanent canine in a human specimen of Mousterian youth in France was estimated to be 40,000 years old. † Bluestone initially described this anomaly in living patients, 2 and a contemporary incidence of an impacted lower canine is reported to range from 0.35% to 0.44%. 3 Orthodontic management of these teeth is often challenging as success is related to the availability of the arch space.

Accurate diagnosis and treatment planning as well as an aetiological assessment of the dental arch are essential when considering impacted teeth. A space deficiency has been suggested as the main aetiological factor related to eruption disturbances of the mandibular canine. 4 A recent report has indicated the possibility of biologic or genetic causes of impacted mandibular canines by recognising a close association with Class II division 2 malocclusions. 5 McConnell et al. implicated a deficiency in maxillary arch width as a local mechanical cause of palatally-impacted canines. 6 It is not known whether a deficiency in mandibular arch width, alterations in mandibular arch form and/or an arch-length – tooth-size discrepancy (AP-TSD) could lead to eruption disturbances of the mandibular canine and impact on its treatment outcome. The present study therefore aimed to test the null hypothesis that there is no difference in mandibular arch parameters
in patients presenting with impacted permanent mandibular canines compared with patients whose lower canines had erupted uneventfully.

Materials and methods
Following approval of the institutional review board, a cross-sectional clinical study was designed and undertaken in the Department of Orthodontics, Purvanchal Institute of Dental Sciences (P.I.D.S), Gorakhpur. The research was conducted in accordance with the ethical principles incorporated in the Declaration of Helsinki.

Using a multistage sampling technique, schools of the district of Gorakhpur were visited in order to select subjects with impacted permanent mandibular canines. The district was divided into six zones based on the records of the Gorakhpur Municipal Corporation. A list of the middle and high schools was obtained for each zone and two schools were randomly selected from each list. Students from each of the selected schools who were at least 14 years of age and who provided written informed parental consent for study participation were assessed. Initially, a total of 10,422 subjects (Females:Males, 0.9:1) were screened. Sixty-seven subjects lacked any clinical sign of eruption of at least one permanent mandibular canine. All were referred to the Department of Orthodontics, P.I.D.S for subsequent examination. Of the 63 subjects who reported to the department and who were subjected to detailed clinical and radiographic investigations (orthopantomograph, occlusal, intra-oral periapical views), 59 were diagnosed with permanent mandibular canines impaction.

A mandibular canine was accepted as impacted:
1. if it was unerupted and showed radiographic evidence of complete root formation; 7
2. if it was identified to be prevented from erupting either by a physical barrier or because of its orientation in a position other than vertical within the alveolus; 7 and/or,
3. when it remained in the jaw two years after the expected mean age of its eruption. 8

In deference to the above factors, a 14-year age cut-off criterion was established for the diagnosis of impaction.

The following factors led to the exclusion of 11 subjects: (1) factors relating to the clinical or radiographic evidence of supernumerary teeth, odontoma or cyst; (2) several impacted and/or congenitally missing teeth, excluding third molars; (3) a history of trauma, previous orthodontic treatment or extraction of any primary or permanent tooth; (4) the presence of gross interproximal caries, orofacial clefts or any other hereditary, syndromic or systemic anomaly; and (5) previous endodontic treatment of primary mandibular canines which possibly influenced the eruption of the permanent canine.

Forty-eight subjects (Females:Males, 1.5:1) were finally considered for inclusion in the ‘impaction group’ (IG). All subjects were Indian by origin and ranged from 14–16 years of age with the mean of 15.03 ± 0.49 years. Dental models were obtained for each subject.

A ‘control group’ (CG), as a reference sample, consisted of study models gathered from 96 age-, gender- and malocclusion-matched Indian subjects who were randomly selected from the screened initial subjects, but who had complete eruption of both permanent mandibular canines.

Using study models and a specially tipped electronic digital caliper (Digimatic caliper; Mitutoyo, Kawasaki, Japan), the following measurements were taken to the nearest 0.01 mm:

1. Anterior and posterior arch width: anterior arch width was defined as the inter-premolar width (IPW) and taken as the distance between the facial contact points between the first and second mandibular premolars on each side. Posterior arch width (inter-molar width, IMW) was defined as the distance between the mesio-buccal cusps of the right and left permanent mandibular first molars (Figure 1). 9

2. Arch length (AL): arch length was defined as a distance from the incisal edge of the mandibular central incisors to the line that linked the distal end of the right and left permanent mandibular first molars. 10 If difficulty was encountered in determining the location of the incisal edge of the central incisors for reasons of rotation or crowding, the measurement was taken from the most labial side. Arch length was also used to evaluate mandibular arch shape using the formula: (AL/IMW) x 100 (Figure 1).

3. Space status/AP-TSD: space was calculated by subtracting total tooth size (TTS) from arch
perimeter (AP). The mesio-distal width of each tooth was measured from the mesial anatomical contact point to the distal contact point and summed to calculate TTS. The width of the impacted canine was judged to be equal to that of the contralateral permanent canine in cases of unilateral canine impaction, while it was substituted with the standard values in cases with bilateral impaction. The AP was measured by dividing the dental arch into segments that could be measured as straight line approximations, viz. AP1-AP4, and subsequently generating a total (AP = AP1+AP2+AP3+AP4) (Figure 1). All measurements were repeated by a single examiner (SJ) who was blinded to the null hypothesis. The average value was used for analysis, and to measure examiner reliability 10 randomly selected subjects from each group were evaluated two weeks later and compared using Dahlberg’s formula.

**Statistical analysis**

Data consisting of age, gender, IPW, IMW, AL, arch shape, individual and TTS, AP and AP-TSD were collected and entered into a spreadsheet (Excel 2000, Microsoft Corporation, WA, USA). Analyses were conducted using SPSS (version 17, IL, USA).

The average values and standard deviations for each measured or calculated variable in the two groups were computed. Independent 2-sample t-tests were carried out for inter-group comparison of IPW, IMW, AL, arch shape, TTS, AP and AP-TSD. A chi-square test assessed the difference in distribution of subjects with spaced, well aligned, mild, moderate and severe crowding in the mandibular arch between the IG and CG. The level of statistical significance was set at 5%.

**Results**

Table I summarises the distribution of subjects with impaction of permanent mandibular canines according to location and gender. The results of the error study were considered sufficiently reliable as the error standard deviations for IPW, IMW, AL, individual tooth measurements and AP were calculated to be 0.21, 0.31, 0.28, 0.000 (mandibular left central incisor), 0.004 (mandibular left second premolar) and 0.34 mm respectively.

The average and standard deviations for each measured or calculated variable in the two groups are provided in Table II. Independent 2-sample t-tests showed statistically significant differences in AL (p = 0.03), arch shape (p = 0.02), TTS (p = 0.04) and AP-TSD (p = 0.01) discrepancies (Table II). The prevalence of the subjects with spaced, well aligned, mild, moderate and severe crowding in the mandibular arch was significantly different between the IG and CG groups (Table III, p = 0.010, chi-square test).

**Discussion**

As permanent canines are important functionally, aesthetically and morphologically, they are appropriately referred to as the ‘cornerstones of dental arches’. Impacted canines would, therefore, be expected to influence dental arch form. It is considered that this is one of the first studies to attempt to identify selected characteristics of the mandibular arch in subjects presenting with the impaction of permanent mandibular canines. It is further considered that the results may contribute to an enhancement of orthodontic therapy, an improvement in post-treatment stability and the reduction of relapse.

It was determined that the inter-group difference in anterior (IPW) and posterior (IMW) arch width between the IG and CG lacked statistical significance. Accordingly, it is likely that a transverse deficiency of the mandibular arch does not play a significant aetiological role in the impaction of lower canines.

The statistically significant decrease in the AL in the IG when compared with the CG indicates shorter dental arches in subjects affected by impaction. A possible contributing factor leading to shortened
dental arches in IG subjects could be an uprighting of the incisors owing to a lack of support, normally provided by erupted canines.

The evaluation of arch space showed that the IG demonstrated significantly greater AP-TSD in comparison with the controls. This was attributed to the significantly greater TTS noted in the IG rather than the inter-group difference in arch perimeter, which was not statistically significant.

An additional and relevant finding of the present study was the statistically significant increase in the level of crowding in subjects with impaction. The proportion of subjects with spaced, well aligned, mild, moderate and severe crowding in the lower arch was significantly different between the two groups. In contrast to 85.41% of the control group, only 55.21% of the impaction group presented with mild (12.50%), moderate (2.96%) or severe (18.75%) crowding (Table III). From an aetiologic perspective, as the lower canines normally erupt before the mandibular premolars, it is unlikely that crowding or a space deficiency would lead to the impaction of the canines.5,15 The premolars are more likely to be affected and so it is reasonable to assume that the association between AP-TSD and impacted mandibular canines may not be purely mechanical or causal but, rather, non-causal and biologically or genetically related due to wider tooth dimensions in the IG.5,16 This concept is supported by previous reports, which confirm a growing body of evidence identifying a complex combination of genetically-controlled dental disturbances.5,17,18

### Table I. Distribution of subjects with impaction of permanent mandibular canine/s.

|                  | Unilateral PMC impaction | Bilateral PMCs impaction | Total       |
|------------------|--------------------------|--------------------------|-------------|
| Females          | 28                       | 4                        | 32 (66.67%) |
| Males            | 13                       | 3                        | 16 (33.33%) |
| Total            | 41 (85.42%)              | 7 (14.58%)               | 48 (100%)   |

PMC, Permanent mandibular canine

### Table II. Inter-group statistical comparison of various measurements/calculations.

| Measurements/calculations | Impaction group [N = 48] | Control group [N = 96] | Difference | p     |
|---------------------------|---------------------------|-------------------------|------------|-------|
| IPW (mm)                  | 4.01                      | 3.93                    | 0.08       | 0.06  |
| IMW (mm)                  | 4.32                      | 4.55                    | -0.23      | 0.05  |
| AL (mm)                   | 2.12                      | 3.43                    | -1.31      | 0.03* |
| Arch shape, AL/IMW x 100  | 73.08                     | 74.56                   | -1.48      | 0.02* |
| Total tooth sizes (mm)    | 68.34                     | 67.8                    | 0.54       | 0.04* |
| AP (AP1+AP2+AP3+AP4) (mm) | 64.87                     | 65.12                   | -0.25      | 0.05  |
| AP-TSD discrepancy (mm)   | -4.45                     | -2.33                   | 2.22       | 0.01* |

* p < 0.05 (statistically significant), Independent 2-sample t-tests.

IPW, inter-premolar width; IMW, inter-molar width; AL, arch length; AP, arch perimeter; AP-TSD, arch-length – tooth-size discrepancy.

### Table III. Number of subjects presenting with or without crowding in the mandibular arch in the impaction and control groups.

| Arch-perimeter – tooth-size discrepancy | Impaction group [N = 48] | Control group [N = 96] | p     |
|----------------------------------------|--------------------------|-------------------------|-------|
| Spacing                                | 3 (6.25%)                | 20 (20.83%)             | p = 0.010* |
| Well aligned                           | 4 (8.33%)                | 23 (23.96%)             | Chi-square = 13.202 |
| Mild crowding (< 4 mm)                 | 11 (22.91%)              | 12 (12.50%)             | Degree of freedom = 4 |
| Moderate crowding (4–8 mm)             | 16 (33.33%)              | 23 (23.96%)             |       |
| Severe crowding (> 8 mm)               | 14 (29.17%)              | 18 (18.75%)             |       |

* p < 0.05 (statistically significant), Chi square test
The inter-group differences observed in the present study may not be enough to be clinically acknowledged. Furthermore, it was not possible to investigate the differences in mandibular arch form between unilateral and bilateral mandibular canine impaction cases owing to the limited sample size (Table I). While the adequacy of the mandibular arch width supports a ‘non-extraction’ approach to treatment, the AP-TSD indicates an ‘extraction’ approach should be followed. In view of the apparent contradictions, the above results should be considered preliminary and a more extensive study to gather further data is recommended. It will be revealing, in the light of the present clinical results, to employ posteroanterior cephalometric projections and cone beam computed tomography for additional analyses of mandibular arch parameters.

**Conclusion**

Evidence is presented to show that subjects with permanent mandibular canine impaction have sufficiently wide but shorter mandibular arch forms, in comparison with a control sample. Furthermore, affected subjects demonstrated a greater AP-TSD, attributed to increased tooth width.

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