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# "Evaluation of Correlation of the Cephalometric Measurements with Mandibular Crowding: A Cephalometric Study"

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***Abstract***
***Introduction:*** *Crowding is the one of the most common problems motivating the patient to seek orthodontic treatment. Only few studies are available on the evaluation of the cephalometrics with mandibular crowding in the same population. The objective of this study was to compare cephalometric measurements in permanent dentition.*
***Material and methods:****It was conducted on the dental casts and lateral cephalograms of 100 subjects (40 males and 60 females) between 16 years to 25 years of age, who were divided into two groups according to the presence or absence of mandibular crowding (50 crowed and 50 non crowed). The crowded sample included those in which dental crowding of more than 1 mm was present and noncrowded sample had tooth size-arch length discrepancy between +1 to-1mm.*
***Conclusion:*** *We found statistically significant inverse correlation between mandibular crowding, effective length of mandible, and lower incisor inclination, however no correlation was found between anterior cranial base length and effective length of maxilla with the degree of mandibular crowding. We conclude that dental crowding is a multifactorial dynamic process that may be influenced by various dental and paradental factors.*
***Key words****: Crowding, tooth size, arch length, cephalometric measurements*
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## I. Introduction

Dental crowding, a discrepancy between tooth size and arch size that results in malposition and/or rotation of teeth[1], is one of the most common problems motivating the patients to seek orthodontic treatment. Association of tooth size and arch dimensions with crowding is the one of the most studied areas in orthodontics. There are many cephalometric factors that have been attributed to cause incisor crowding. These include effective length of maxilla and mandible, anterior cranial base length and lower incisor inclination. Only a few studies have evaluated the relationship between crowding and cephalometric measurements in same population. The relevance of studying these parameters in causing mandibular crowding in the local population is of paramount importance. Turkkahramana and Sayin[2] compared patients with and without anterior crowding who presented Class I facial pattern in the early mixed dentition. They observed that patients with incisor crowding showed a shorter maxillary and mandibular length. Janson *et al*[1] compared patients with Class II malocclusion with and without anterior crowding in permanent dentition, and observed that decreased maxillary and mandibular effective lengths constitute an important factor associated with dental crowding. This study was conducted to determine the association of all these parameters with occurrence of mandibular crowding in the ethnic group representing local population of Uttar Pradesh (India).

## II. Materials And Methods

This study was carried out at Department of Orthodontics and Dentofacial Orthopaedics of a dental college and hospital in North India. Dental casts and lateral cephalograms of 100 consecutive subjects (40 males and 60 females between 16 to 25 years of age) included in this study, were divided into two groups according to the presence or absence of mandibular crowding. All cast and cephalometric analysis were done by same investigator to avoid interobserver variability. One month after first measurements, 10 pairs of dental casts were remeasured and 10 randomly selected radiographs were retraced and redigitized. Casual errors were calculated according to Dahlberg's formula - $Se^2 = \Sigma d^2/2n$, where $Se^2$ is the error variance and d is the difference between two determinations of the same variable. Systematic errors were evaluated with dependent t-tests at a significance level of 5%. The errors were found to be insignificant (as $p>0.005$) for all measurements. Crowding was calculated in each arch as the numerical difference between the arch perimeter and the sum of mesiodistal tooth size from the right side second premolar to left side second premolar. The images of all radiographs were imported into the Dolphin Imaging 10.5 Software (Dolphin Imaging and Management Solutions, Chatsworth, Calif). The landmarks were identified and digitalized on-screen to get a digital tracing. Fifteen landmarks were identified and recorded, and fifteen angular/linear measurements were obtained. The midpoint of a bilateral structure was taken if present.

**Cephalometric angular and linear measurements (Figure 1)**

- ANB angle (Downs)
- Gonion-gnathion to SN angle (Steiner)
- Y axis (Downs)
- IMPA (Tweed)
- FMIA (Tweed)
- UI-SN
- Upper incisor to NA angle (Steiner) (UI-NA)
- Lower incisor to NB angle (Steiner) (LI-NB)
- Lower incisor to FH plane (LI-FH)
- Inter-incisal angle
- Upper incisor to NA distance (Steiner)
- Lower incisor to NB distance (Steiner)
- WITS appraisal (Wits)
- Anterior cranial base length (N-S)
- Effective length of mandible (Co-Gn) (Mc Namara)
- Effective length of maxilla (Co-A) (Mc Namara)

The data were tabulated and statistically analyzed using the S.P.S.S. (Version 17, IBM, USA) statistical analysis package software. Mean, standard deviation (SD), minimum and maximum values were calculated for each group. To find out any significant differences among these measurements between groups, independent 't' test was applied. Pearson correlations were examined for interrelationships between crowding and significant parameters. Statistical significance was tested at p levels (highly significant: p value $< 0.01$, significant: p value $< 0.05$, insignificant: p value $> 0.05$).

## III. Results

The distribution of sample according to sex, dental arch, and crowding is shown in table I. The error was found to be insignificant (as $p > 0.005$) for all measurements (table II). It is observed that inclination of the lower incisor is associated with mandibular crowding in the permanent dentition. All measurements related to lower incisors were smaller in the crowded group except LIFH and inter-incisal angle, which were larger in the crowded group. There was no correlation between upper incisor inclination and mandibular crowding. Effective length of mandible (Co- Gn) was used to compare the sagittal dimensions of the mandible in cases with and without crowding. Mandibular effective length (Co-Gn) was significantly smaller in crowded males and females both. No association was found between the effective lengths of maxilla (Co-A) and the degree of mandibular crowding at the permanent dentition stage (table III). No correlation was present between anterior cranial base and degree of mandibular crowding. No correlation was present between ANB angle and WITS appraisal, however the values were larger in the crowded group, indicating tendency toward a Class II jaw dysplasia. Thus, we can state that mandibular anterior crowding is more likely to occur in retrognathic cases. In our study results did not exhibit any significant difference in measurements regarding the growth direction of the mandible. Mean values of the gonion-gnathion to SN line and that of Y axis angles were similar in crowded and noncrowded groups and there was no association between the growth direction of the mandible and the degree of mandibular crowding at the permanent dentition stage.

In Pearson correlations of significant cephalometric measurements with degree of mandibular crowding; LI-MP angle, LI-NB (linear), LI-NB angle and effective length of mandible were inversely proportional, whereas, LI-FH angle was directly proportional with degree of mandibular crowding in both groups (Graph 1).

## IV. Discussion

Crowding of teeth is a very important diagnostic criterion for the treatment planning. The amount and location of crowding is very important to determine how the crowding should be relieved. Since the commonest cause of dental crowding is tooth size - jaw size and tooth size - arch width discrepancy, many investigators have carried out biometric studies of tooth size and dental arches. In the present study cephalometric measurements in noncrowded and crowded groups have been compared and correlated with degree of mandibular crowding.

In evaluation of crowding it is important to consider the axial inclination of teeth as it also contributes to crowding. If the incisors are retroclined lingually they accentuate crowding; but if the incisors protrude, the potential crowding will at least partially be alleviated. Crowding and protrusion are really different aspects of the same phenomenon. If there is not enough space for the teeth, the result can be crowding, protrusion or combination of both[5]. The purpose of our study was to measure the actual crowding without considering the axial inclination of the tooth. Therefore, the measurements were made for arch perimeter by adapting a length of brass wire (diameter, 0.020 inch) to lie over the incisal edges of the maximum anterior teeth which present at the line of arch and the centres of the contact areas of the teeth in the buccal segments. The brass wire was shaped into a smooth arch form, free from kinks.

Maxillary crowding is less frequent than mandibular crowding as only 28/50 (12/20 males and 16/30 females) subjects showed maxillary crowding whereas mandibular crowding was present in all the 50 subjects in group with crowding. Fastlicht J.[6] postulated that functional forces tend to change the axial inclination of the teeth and crowding results as a compensatory mechanism. Brodie AG[7] indicated that the maxillary incisors receive a separating impulse with each stroke of mastication, while the mandibular incisors tend to come into closer contact.

Retrusion of lower incisors has been found to be significantly correlated with mandibular crowding. Sanin and Savara[8] found in their longitudinal study that children with no crowding in the permanent dentition had more labially inclined mandibular incisors in the mixed dentition. On the other hand, Bishara et al[9] stated that the uprighting of the incisors could not, by itself, be a determinant of the severity of the anterior or total change in arch length discrepancy. Our results revealed that inclination of the lower incisor is associated with mandibular crowding in the permanent dentition. All measurements related to lower incisors were smaller in the crowded group except LI-FH and inter-incisal angle, which were larger in the crowded group. Among these, statistically significant differences were noted in LI-MP, LI-FH, LI-NB (angle) in both males and females but when overall crowded and noncrowded groups were compared inter-incisal angle also showed significant difference.

It is well known that retrusion of teeth results in reduction of arch length. Our result also showed that LI-MP, LI-NB (angle) inversely correlate with degree of mandibular crowding (Graph 1). Therefore, oral habits like thumb or lip sucking must be avoided in the mixed dentition stage. These habits often cause retrusion of lower and protrusion of upper incisors and result in mandibular anterior crowding. Any correlation between upper incisor inclination and mandibular crowding could not be found in this study.

Berg R.[10] compared cephalometric variables of patients with and without crowding and found that variables related to lower jaw dimensions (Ar-Po, SNB) had significantly smaller values in the crowded group. Several other reports have also indicated that crowding occurred more frequently in less prognathic cases[78]. In this study, we used effective lengths of mandible (Co- Gn) to compare the sagittal dimensions of the mandible in cases with and without crowding. Mandibular effective length (Co-Gn) was significantly smaller in both crowded males and females. The results of this study were in accordance with Janson et al,[1] Turkkahramana et al[2] and Leighton and Hunter[11] who found shorter mandibular body length in cases with crowding. In present study no association was found between the effective lengths of maxilla (Co-A) and the degree of mandibular crowding at the permanent dentition stage.

Melo et al[12] and Turkkahraman and Sayin[2] compared cephalometric measurements of patients with and without crowding and found difference between groups in the anterior cranial base variable but the relationship was not strong enough to differentiate the crowded group from the normal group. In this study no correlation was present between anterior cranial base and degree of mandibular crowding. No correlation was found between ANB angle and WITS appraisal but the value is larger in the crowded group, indicating a tendency toward a Class II jaw dysplasia. Thus, we can state that mandibular anterior crowding is more likely to occur in retrognathic cases. Leighton and Hunter [11] reported that downward and deficient growth of the mandible with both upright or retroclined mandibular incisors was associated with crowding. However our results did not exhibit any significant difference in measurements regarding the growth direction of the mandible. Mean values of the gonion-gnathion to SN line and Y axis angles were all similar in crowded and noncrowded groups. Therefore, we can conclude that both forward and backward rotating underlying patterns may have a considerable effect on the environment for the alignment of the teeth.

## V. Conclusion

It is concluded that significant inverse correlation exists between mandibular crowding and effective length of mandible, lower incisor inclination to NB plane, and mandibular plane, however there is no correlation of anterior cranial base length and effective length of maxilla with degree of mandibular crowding. This study helps us to understand the multifactorial origin of the dental crowding. Other factors such as arch shape, axial inclination of posterior tooth, depth of curve of Spee, potential of alveolar growth, facial type, soft tissue morphology, habits, and growth pattern expression could also be predictors of dental crowding. Future studies considering additional factors would further help in solving mystery of this intricate phenomenon of crowding of teeth.

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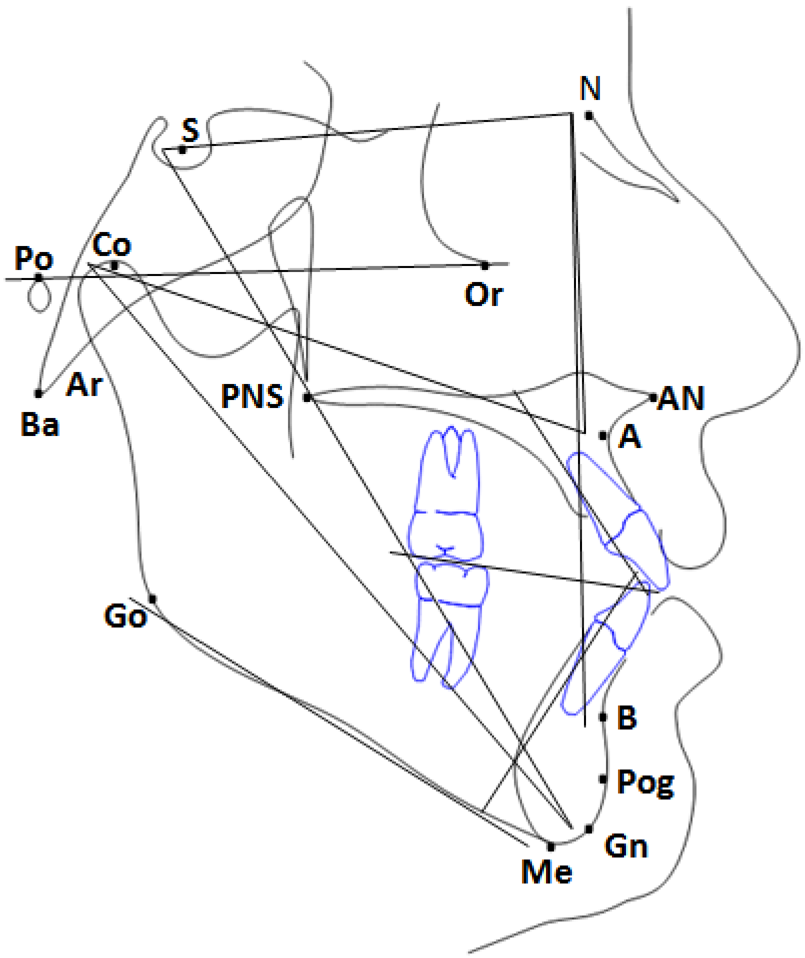



**Figure 1: Cephalometric angular and linear measurements**

**Table I. Distribution of samples according to sex and arch**

| SEX | ARCH | SAMPLE DATA | GROUPS | | Total |
|---|---|---|---|---|---|
| | | | NONCROWDED | CROWDED | |
| F | MANDIBLE | NUMBER | 30 | 30 | 60 |
| | | PERCENTAGE | 50.0% | 50.0% | 100.0% |
| | MAXILLA | NUMBER | 44 | 16 | 60 |
| | | PERCENTAGE | 73.3% | 26.7% | 100.0% |
| M | MANDIBLE | NUMBER | 20 | 20 | 40 |
| | | PERCENTAGE | 50.0% | 50.0% | 100.0% |
| | MAXILLA | NUMBER | 28 | 12 | 40 |
| | | PERCENTAGE | 70.0% | 30.0% | 100.0% |

**Table II: The errors of the method for cephalometric measurements by Dahlberg's method, Pearson's correlation co-efficient and the Dependent paired t-test**

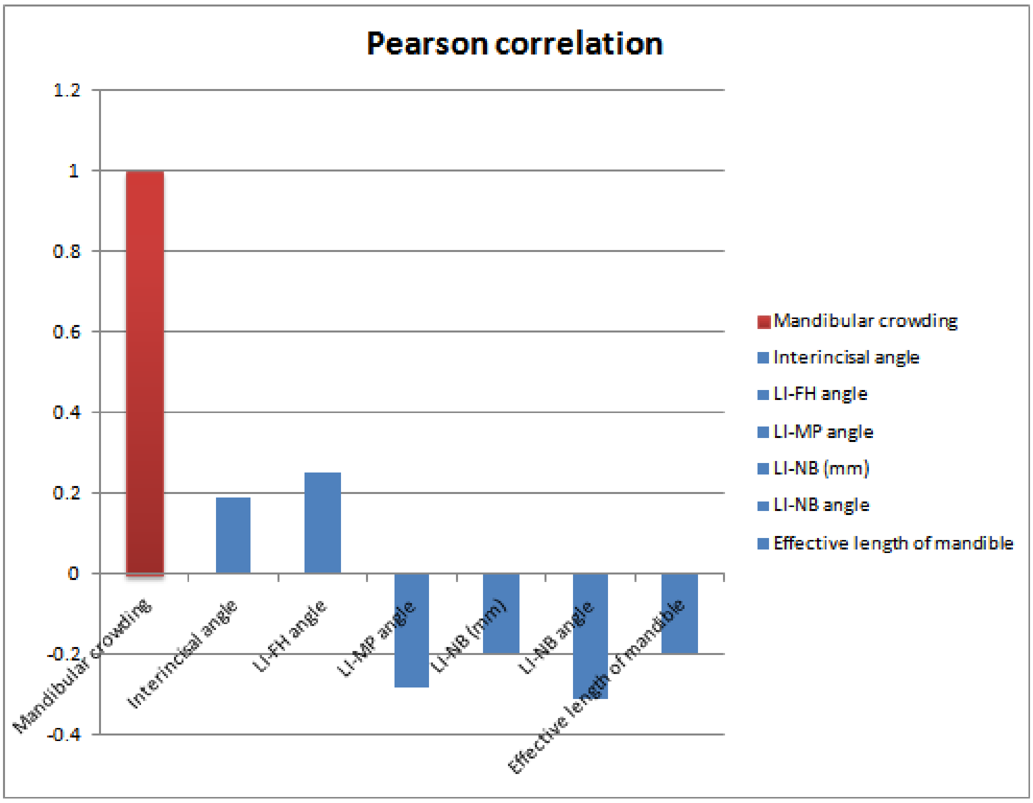
| | DM | R | t-test | P |
|---|---|---|---|---|
| **ANB** | 0.107 | 0.105 | 0.025 | P>0.05 |
| **WITS** | 0.106 | 0.106 | 0.000 | P>0.05 |
| **SNGOGN** | 0.260 | 0.260 | 0.007 | P>0.05 |
| **Y -AXIS** | 0.151 | 0.151 | 0.012 | P>0.05 |
| **INTER INCISAL** | 0.380 | 0.380 | 0.014 | P>0.05 |
| **UI-SN** | 0.239 | 0.239 | 0.011 | P>0.05 |
| **UI-NA(mm)** | 0.137 | 0.136 | 0.013 | P>0.05 |
| **UI-NA** | 0.335 | 0.335 | 0.005 | P>0.05 |
| **LI-FH** | 0.224 | 0.223 | 0.008 | P>0.05 |
| **LI-MP** | 0.269 | 0.270 | 0.016 | P>0.05 |
| **LI-NB (mm)** | 0.081 | 0.081 | 0.022 | P>0.05 |
| **LI-NB** | 0.212 | 0.212 | 0.008 | P>0.05 |
| **EL OF MANDI** | 0.258 | 0.258 | 0.007 | P>0.05 |
| **SN** | 0.194 | 0.194 | 0.018 | P>0.05 |

D.M. = Dahlberg's method, r = Pearson's correlation coefficient, P = Level of significance.

**Table III. Independent t test results for comparison of cephalometric measurements in crowded and noncrowded group**

| | Group | N | Mean | SD | t-test | p-value | NS/S |
|---|---|---|---|---|---|---|---|
| **ANB** | CR | 50 | 2.93 | 3.14 | 0.221 | 0.825 | NS |
| | NCR | 50 | 2.81 | 2.62 | | | |
| **WITS** | CR | 50 | -0.12 | 3.62 | 0.922 | 0.359 | NS |
| | NCR | 50 | -0.75 | 3.23 | | | |
| **SNGOGN** | CR | 50 | 31.10 | 6.87 | 0.958 | 0.340 | NS |
| | NCR | 50 | 29.85 | 6.16 | | | |
| **Y-AXIS** | CR | 50 | 60.60 | 4.16 | 0.690 | 0.492 | NS |
| | NCR | 50 | 60.06 | 3.73 | | | |
| **INTER INCISAL** | CR | 50 | 124.91 | 13.85 | 2.369 | 0.020 | S |
| | NCR | 50 | 118.96 | 11.11 | | | |
| **UI-SN** | CR | 50 | 108.92 | 9.50 | 0.610 | 0.543 | NS |
| | NCR | 50 | 110.00 | 8.17 | | | |
| **UI-NA (mm)** | CR | 50 | 6.73 | 4.08 | 0.492 | 0.624 | NS |
| | NCR | 50 | 6.35 | 3.67 | | | |
| **UI-NA** | CR | 50 | 27.12 | 10.44 | 0.003 | 0.997 | NS |
| | NCR | 50 | 27.13 | 8.04 | | | |
| **LI-FH** | CR | 50 | 60.51 | 10.33 | 2.683 | 0.009 | S |
| | NCR | 50 | 55.77 | 7.02 | | | |
| **LI-MP** | CR | 50 | 92.71 | 8.71 | 3.836 | 0.000 | S |
| | NCR | 50 | 98.59 | 6.45 | | | |
| **LI-NB(mm)** | CR | 50 | 5.45 | 3.47 | 2.460 | 0.016 | S |
| | NCR | 50 | 6.99 | 2.72 | | | |
| **LI-NB** | CR | 50 | 25.06 | 8.74 | 3.905 | 0.000 | S |
| | NCR | 50 | 31.09 | 6.55 | | | |
| **EL OF MAXI** | CR | 50 | 86.54 | 5.64 | 1.937 | 0.056 | NS |
| | NCR | 50 | 86.66 | 5.29 | | | |
| **EL OF MANDI** | CR | 50 | 113.67 | 7.52 | 2.574 | 0.012 | S |
| | NCR | 50 | 117.29 | 6.50 | | | |
| **SN** | CR | 50 | 71.52 | 4.84 | 0.033 | 0.974 | NS |
| | NCR | 50 | 71.55 | 4.19 | | | |

**Graph 1: Pearson correlation results**
**Correlation of significant cephalometric measurements with degree of mandibular crowding**

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