Cephalometric norms for orthognathic surgery for North Indian population

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Abstract

Objective: The objective of this study is to establish the cephalometric hard tissue norm for orthognathic surgery for North Indian subjects. Materials and Methods: A total of 100 young adults which consists of 46 males and 54 females with the age range of 14-24 years with balanced facial profile and minimum arch length discrepancies were chosen for the study. Lateral cephalograms with teeth in occlusion were recorded and analyzed manually to establish the norm. The mean values of various cephalometric hard tissue variables for North Indian males and females were compared with those Caucasians. Results: All the cephalometric parameters for orthognathic surgery except mandibular length and lower incisor inclination were comparable among North Indian males and females. The mandibular length was significantly more among North Indian males than females (P < 0.05) and the inclination of lower incisors was significantly more among North Indian females than males (P < 0.05). However, many of the cephalometric parameters for orthognathic surgery were significantly different among North Indian and Caucasian males and females. Conclusion: The cephalometric norms for orthognathic surgery were established for North Indians and many measurements were different from those for Caucasians.

Keywords: Cephalometric norms, orthognathic surgery, North Indians

Introduction

Skeletal, dentoalveolar and softtissue harmony reflects the balance of the face. The correction of dental malocclusion, improvement in facial appearance and long-term stability of results are the three main objectives of orthognathic surgery in patients with facial disharmony. If anatomical corrections are to be achieved within physiologically stable limits, diagnostic assessment and treatment planning are important. For any individual, the successful treatment of orthognathic surgery depends upon careful diagnosis. Cephalometric analysis is used as an aid in the diagnosis of skeletal and dental problems in the field of Oral Surgery and Orthodontics. Original analysis of the cephalometric for orthognathic surgery (COGS) is especially used for diagnosis and treatment planning for cases requiring orthognathic surgery and it is based largely upon rectilinear measurements. Although a number of cephalometric analysis are commonly used for orthodontic case analysis and are primarily used to harmonize the position of teeth with the existing skeletal bases, however limited number of studies have been carried out to develop COGS norms, related to specific population groups. It is well-established that surgical cephalometric analysis developed for Caucasian populations is different from other racial groups and the same cannot be used in all ethnic groups. In India, diagnosis and treatment planning for all the patients requiring orthognathic surgery is usually done based on Caucasian norms. Hence, the COGS norm for the North Indians would be useful in providing specific values for diagnosis and treatment planning for the orthognathic surgery. Thus, the present study was conducted to develop COGS norms for North Indians.

Materials and Methods

A total of 100 North Indian adolescents or young adults (46 males, 54 females) in the age range of 14-24 years were included in the study. The selected subjects were chosen from the pre-treatment records of patients undergoing orthodontic treatment in the Unit of Orthodontics, Oral Health Sciences Centre, Postgraduate Institute of Medical Education and Research, Chandigarh, India. All the subjects had pleasing facial profile (orthognathic facial profile), bilateral Angle’s Class I molar relationship, full complement of permanent teeth and with minimum to moderate arch length discrepancies (i.e., crowding or spacing ≤5 mm as calculated by Carey’s method). Subjects who had the history of orthodontic treatment and transverse and vertical jaw discrepancies were excluded from the study. All the cephalograms were recorded with teeth in centric occlusion and in the same machine. All the cephalograms were traced...
 manually and the tracings were reviewed on two separate occasions by two of the investigators for accurate landmark identification. The same investigator (SPS) analyzed all the cephalograms. The method of cephalometric analysis was strictly followed as suggested by Burstone et al. The COGS norms for North Indians were established and compared with the norms for Caucasians to determine whether any of the North Indian norms were statistically different from the Caucasian norms.

Statistics
A master file was created and the data was statistical analysed on a computer by using Statistical package for Social Sciences software (SPSS Inc., Chicago, IL, version 15.0 for Windows). The mean and standard deviations for the various parameters were determined for each gender. Unpaired t-test was used to determine the mean differences for each cephalometric measurement between the North Indian subjects and the Caucasians. The probability value (P value) 0.05 was considered as statistically significant level.

Results
The mean values of various cephalometric parameters for North Indian males and females are described in Table 1. All the cephalometric parameters except mandibular length and lower incisor inclination were comparable among North Indian males and females. Mandibular length was significantly more among North Indian males than females (P < 0.05). Inclination of lower incisors was significantly more among North Indian females than males (P < 0.05). The comparisons between mean values of North Indian males and females to those of Caucasian males and females are presented in Tables 2 and 3; and in Figures 1 and 2 and Figures 3 and 4 respectively. The anterior cranial base length was comparable among the two populations, but the posterior cranial base length was significantly more among North Indian females than Caucasian females. Maxillary and mandibular protrusions were significantly less among North Indians than Caucasians (P < 0.001). Chin protrusion among Caucasians was significantly more (P < 0.05). Upper anterior face height was significantly more among North Indian females than Caucasian females (P < 0.01), but lower anterior face height was significantly less among North Indian males than Caucasian males (P < 0.001). Dental heights were significantly more among Caucasian males. Mandibular plane angle was comparable among North Indians and Caucasians. Maxillary length, mandibular length and chin depth were comparable among females of both the ethnic groups, but were more among Caucasian males than North Indian males. The inclination of upper incisors and upper occlusal plane were significantly more among North Indians than Caucasians. The Wits value was also significantly more among North Indians than Caucasians.

Discussion
Cephalometric norms are most commonly used in orthodontics and their accurate use is essential in setting norms for different racial groups in growth prediction, diagnosis and treatment planning. Many of the studies have been reported in the literature mentioning the cephalometric norms among various populations. Altemus[6,7] found a greater absolute size of Black children’s heads and more dental protrusion,
### Table 1: Various skeletal and dental parameters among North Indian males and females

| Cephalometric parameters                  | Description of parameters | Mean±SD | Comparison |
|------------------------------------------|---------------------------|---------|------------|
| **Cranial base**                         |                           |         |            |
| Anterior cranial base (mm)               | PTM-N ("HP")             | 52.94±2.90 | 52.57±4.13 | NS         |
| Posterior cranial base (mm)              | Ar-PTM ("HP")            | 36.13±2.78 | 35.11±4.11 | NS         |
| **Horizontal skeletal relations**        |                           |         |            |
| Facial convexity (*)                     | N-A-Pg                    | 4.15±3.70 | 4.53±3.27  | NS         |
| Maxillary protrusion (mm)                | N-A ("HP")               | −4.46±−3.70 | −4.46±−3.62 | NS         |
| Mandibular protrusion (mm)               | N-B ("HP")               | −11.17±6.12 | −11.03±5.30 | NS         |
| Chin protrusion (mm)                     | N-Pg ("HP")              | −10.44±−5.80 | −10.55±−5.42 | NS         |
| **Vertical skeletal and dental relations**|                           |         |            |
| Upper anterior face height (mm)          | N-ANS (PHP)               | 52.12±7.26 | 52.55±3.36 | NS         |
| Lower anterior face height (mm)          | ANS-Me (PHP)              | 62.38±5.72 | 61.85±4.42 | NS         |
| Upper posterior face height (mm)         | PNS-N (PHP)               | 53.08±4.88 | 52.41±4.67 | NS         |
| Mandibular plane angle (*)               | MP-HP                     | 23.35±4.83 | 24.23±3.86 | NS         |
| Upper anterior dental height (mm)        | 1/-NF (PNF)               | 27.28±3.12 | 27.34±3.11 | NS         |
| Lower anterior dental height (mm)        | /1- MP (PMP)              | 40.24±3.65 | 40.16±2.93 | NS         |
| Upper posterior dental height (mm)       | 6/-NF (PNF)               | 22.38±4.84 | 21.91±3.26 | NS         |
| Lower posterior dental height (mm)       | 6/- MP (PMP)              | 32.51±3.55 | 31.19±3.44 | NS         |
| **Maxilla and mandible**                |                           |         |            |
| Maxillary length (mm)                   | PNS-ANS ("HP")           | 50.78±4.60 | 52.48±5.85 | NS         |
| Mandibular length (mm)                  | Ar-Go                     | 49.10±4.99 | 46.91±4.16 | *          |
| Mandibular body length (mm)             | Go-Pg                     | 74.61±5.68 | 75.09±4.90 | NS         |
| Chin depth (mm)                         | B-PG ("MP")              | 6.07±1.70  | 6.15±1.95  | NS         |
| Gonial angle (*)                        | Ar-Go-Me                  | 123.42±4.84 | 122.96±9.75 | NS         |
| **Dental relationships**                |                           |         |            |
| Wits analysis (mm)                      | A-B ("OP")               | −2.46±−2.21 | −2.65±−3.43 | NS         |
| Upper incisor angle                     | 1/-NF                     | 116.67±6.67 | 117.95±8.43 | NS         |
| Lower incisor inclination (*)           | /1- MP                    | 92.21±10.31 | 97.41±10.61 | *          |
| Upper occlusal plane (*)                | OP/- HP                   | 10.44±4.31 | 11.97±3.98 | NS         |
| Lower occlusal plane (*)                | /OP-HP                    | 10.33±4.25 | 11.58±4.28 | NS         |

NS: Non-significant; *P<0.05. SD: Standard deviation

### Table 2: Comparison of various cephalometric parameters between North Indian and Caucasian males

| Cephalometric parameters                  | Description of parameters | Mean±SD | Comparison |
|------------------------------------------|---------------------------|---------|------------|
| **Cranial base**                         |                           |         |            |
| Anterior cranial base (mm)               | PTM-N ("HP")             | 52.94±2.90 | 52.8±4.1  | NS         |
| Posterior cranial base (mm)              | Ar-PTM ("HP")            | 36.13±2.78 | 37.1±2.8  | NS         |
| **Horizontal skeletal relations**        |                           |         |            |
| Facial convexity (*)                     | N-A-Pg                    | 4.15±3.70 | 3.9±6.4   | NS         |
| Maxillary protrusion (mm)                | N-A ("HP")               | −4.46±−3.70 | 0.0±3.7  | ***        |
| Mandibular protrusion (mm)               | N-B ("HP")               | −11.17±6.12 | −5.3±6.7 | **         |
| Chin protrusion (mm)                     | N-Pg ("HP")              | −10.44±−5.80 | −4.3±8.5 | *          |
| **Vertical Skeletal and dental relations**|                           |         |            |
| Upper anterior face height (mm)          | N-ANS (PHP)               | 52.12±7.26 | 54.7±3.2  | NS         |

Contd...
Table 2: Contd...

| Cephalometric parameters                  | Description of parameters | Mean±SD Indian males | Mean±SD Caucasian males | Comparison |
|-------------------------------------------|---------------------------|----------------------|-------------------------|------------|
| Lower posterior face height (mm)          | ANS-Me (PHP)              | 62.38±5.27           | 68.6±3.8                | ***        |
| Upper posterior face height (mm)          | PNS-N (PHP)               | 53.08±4.88           | 53.9±1.7                | NS         |
| Mandibular plane angle (°)                | MP-HP                     | 23.35±4.82           | 23.0±5.9                | NS         |
| Upper anterior dental height (mm)         | 1/-NF (PNF)               | 27.28±3.12           | 30.5±2.1                | ***        |
| Lower anterior dental height (mm)         | 1/-MP (PMP)               | 40.24±3.65           | 45.0±2.1                | ***        |
| Upper posterior dental height (mm)        | 6/-NF (PNF)               | 22.38±4.84           | 26.2±2.0                | ***        |
| Lower posterior dental height (mm)        | 6/-MP (PMP)               | 32.51±3.55           | 35.8±2.6                | **         |

Maxilla and mandible

| Maxillary length (mm)                     | PNS-ANS ("HP)            | 50.78±4.60           | 57.7±2.5                | ***        |
| Mandibular length (mm)                    | Ar-Go                     | 49.10±4.99           | 52.0±4.2                | *          |
| Mandibular body length (mm)               | Go-Pg                     | 74.61±5.68           | 83.7±4.6                | NS         |
| Chin depth (mm)                           | B-PG ("MP)               | 6.07±1.70            | 8.9±1.7                 | ***        |
| Gonial angle (°)                          | Ar-Go-Me                  | 123.42±4.84          | 119.1±6.5               | *          |

Dental relationships

| Wits analysis (mm)                        | A-B ("OP)                | -2.46±-2.21          | -1.1±2.0                | *          |
| Upper incisor angle                       | 1/-NF                     | 116.67±6.67          | 111.0±4.7               | NS         |
| Lower incisor inclination (°)             | 1/-MP                     | 92.21±10.31          | 95.9±5.2                | **         |
| Upper occlusal plane (°)                  | OP/-HP                    | 10.44±4.31           | 6.2±5.1                 | NS         |
| Lower occlusal plane (°)                  | /OP-HP                    | 10.33±4.25           |                        |            |

NS: Non-significant; *P<0.05; **P<0.01; ***P<0.001; SD: Standard deviation

Figure 2: Comparison of various cephalometric parameters between North Indian and Caucasian males. (a) Upper posterior dental height; (b) lower posterior dental height; (c) maxillary length; (d) mandibular length; (e) mandibular body length; (f) chin depth; (g) gonial angle; (h) wits analysis; (i) upper incisor angle; (j) lower incisor inclination; (k) upper occlusal plane

with chin in the same position relative to the cranial base when compared to White children. Connar and Moshiro[15] observed greater maxillary and mandibular prognathism, anterior dental height, lower incisor proclination and lesser nasolabial angle among Blacks than in Whites. Kowalski’s et al.[24] also revealed more proclined lower incisors and more canting of the occlusal plane relative to a cranial base in Blacks than Whites. However, Jacobson[13,14] did a comprehensive study on the craniofacial skeletal pattern of South African Blacks and found no significant difference
from that of Whites in relation to anterior extremity of the maxilla and mandible, maxillary length, anterior face height and Wits measurement; however ANB angle among Blacks was found to be significantly larger. In a critical observation, Richardson\textsuperscript{[16]} concluded that the differences in mean among ethnic or racial groups were often greater than the differences in mean within the ethnic or racial groups. In agreement with the many previous studies,\textsuperscript{[6,7,15-20,24]} our study also revealed significant differences in many cephalometric parameters among North Indians compared with Caucasians. In contrast to our study, Fonseca and Klein\textsuperscript{[12]} presented COGS norms for a variety of cephalometric measurements without using the rectilinear coordinate system and reported greater maxillary and mandibular skeletal prognathism, greater upper and lower incisor proclination, shorter middle face height and longer lower face height for American Negro women. However, in

**Figure 3:** Comparison of various cephalometric parameters between North Indian and Caucasian females. (a) Anterior cranial base; (b) posterior cranial base; (c) facial convexity; (d) maxillary protrusion; (e) mandibular protrusion; (f) chin protrusion; (g) upper anterior face height; (h) lower anterior face height; (i) upper posterior face height; (j) mandibular plane angle; (k) upper anterior dental height; (l) lower anterior dental height; (m) upper posterior dental height

**Figure 4:** Comparison of various cephalometric parameters between North Indian and Caucasian females. (a) Lower posterior dental height; (b) maxillary length; (c) mandibular length; (d) mandibular body length; (e) chin depth; (f) gonial angle; (g) wits analysis; (h) upper incisor angle; (i) lower incisor inclination; (j) upper occlusal plane
Table 3: Comparison of various cephalometric parameters between North Indian and Caucasian females

| Cephalometric parameters | Description of parameters | Mean±SD | Significance |
|-------------------------|---------------------------|---------|-------------|
|                         |                           | North Indian females | Caucasian females |         |
| Cranial base            |                           |         |             |
| Anterior cranial base (mm) | PTM-N (“HP”)             | 52.57±4.13 | 50.9±3.0 | NS         |
| Posterior cranial base (mm) | Ar-PTM (“HP”)           | 35.11±4.11 | 32.8±1.9 | **         |
| Horizontal skeletal relations |                       |         |             |
| Facial convexity (°)   | N-A-Pg                   | 4.53±3.27 | 2.6±5.1 | NS         |
| Maxillary protrusion (mm) | N-A (“HP”)               | -4.46±-3.62 | -2.0±3.7 | *          |
| Mandibular protrusion (mm) | N-B (“HP”)               | -11.03±-5.30 | -6.9±4.3 | **         |
| Chin protrusion (mm)   | N-Pg (“HP”)              | -10.55±-5.42 | -6.5±5.1 | **         |
| Vertical Skeletal and dental relations |           |         |             |
| Upper anterior face height (mm) | N-ANS (PHP)            | 53.55±3.36 | 50.0±2.4 | **         |
| Lower anterior face height (mm) | ANS-Me (PHP)           | 61.85±4.42 | 61.3±3.3 | NS         |
| Upper posterior face height (mm) | PNS-N (PHP)            | 52.41±4.67 | 50.6±2.2 | *          |
| Mandibular plane angle (°) | MP-HP                   | 24.23±3.86 | 24±5.0 | NS         |
| Upper anterior dental height (mm) | 1/-NF (PNF)            | 27.34±3.11 | 27±5.1 | NS         |
| Lower anterior dental height (mm) | /1-MP (PMP)          | 40.16±2.93 | 40±1.8 | NS         |
| Upper posterior dental height (mm) | 6/-NF (PNF)            | 21.91±3.26 | 23.0±1.3 | *          |
| Lower posterior dental height (mm) | /6-MP (PMP)           | 31.91±3.44 | 32.1±1.9 | NS         |
| Maxilla and mandible   |                           |         |             |
| Maxillary length (mm)  | PNS-ANS (“HP”)           | 52.48±5.85 | 52.6±3.5 | NS         |
| Mandibular length (mm) | Ar-Go                    | 46.91±4.16 | 46.8±2.5 | NS         |
| Mandibular body length (mm) | Go-Pg                   | 75.09±4.90 | 74.3±5.8 | NS         |
| Chin depth (mm)        | B-PG (“MP”)             | 6.15±1.95  | 7±1.9   | NS         |
| Gonial angle (°)       | Ar-Go-Me                 | 122.96±9.57 | 122.0±6.9 | NS         |
| Dental relationships   |                           |         |             |
| Wits analysis (mm)     | A-B (“OP”)               | -2.65±-3.43 | -0.4±2.5 | **         |
| Upper incisor angle    | 1/-NF (“OP”)            | 117.95±8.43 | 112.5±5.3 | **         |
| Lower incisor inclination (°) | /1-MP (“OP”)           | 97.41±10.61 | 95.9±5.7 | NS         |
| Upper occlusal plane (°) | OP/-HP                  | 11.97±3.98 | 7.1±2.5 | ***        |
| Lower occlusal plane (°) | /OP-HP                  | 11.58±4.28 | -       | -          |

NS: Non-significant; *P<0.05; **P<0.01; ***P<0.001; SD: Standard deviation

Singh, et al.: COGS for North Indians

In the present study, rectilinear coordinate system was used to compare COGS norms for North Indians with Caucasians taking landmark identification, measurement and techniques as suggested by Burstone et al.[10] and Legan and Burstone[11] to achieve a valid comparison with the original data. In the present study, the mandibular length was significantly more among males than among females, whereas lower incisor inclination was significantly more among females than in the males. The increased inclination of the lower incisor among females could be as compensation secondary to the mandibular retrusion. In the present study, we also observed that the antero-posterior position of the maxilla and mandible was more backward among North Indians than Caucasians and could be due to lesser maxillary and mandibular length in North Indians. Alcalde et al.[19] and Nezu et al.[25] compared cephalometric norms between Japanese and Caucasians and reported shorter maxilla, larger upper anterior face height and lower posterior dental height among Japanese than Burston’s white sample. When we compared the findings of Alcalde et al.[19] and Nezu et al.[25] to those of our finding, the Wits value and upper anterior dental heights in Indians were more than Japanese and Caucasians whereas lower anterior dental height was smaller than Japanese and Caucasian. However, vertical skeletal and dental parameters were larger in Japanese than in North Indians.

The present study revealed that the orthodontic and orthognathic surgical treatment planning for North Indians may be more relevant if the diagnosis is based on the standard measurements specific for this particular racial group. However, these values should not be interpreted as treatment goal.
Conclusion

The cephalometric norms for orthognathic surgery for North Indians were established and the following conclusions were drawn from the parent study:

- Length of the mandible was more among North Indian males than females; whereas inclination of the lower incisor was more among North Indian females than males
- North Indians had more retruded maxilla and mandible, more facial convexity when compared to the Caucasians
- The maxillary and mandibular lengths, chin depth, vertical skeletal and dental heights were more among Caucasians than North Indians
- Upper incisor inclination was more among North Indians
- The Wits value was more among North Indians than among Caucasians.

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