Cephalometric norms for the north Indian population: A systematic review

ABSTRACT

The cephalometric norms for orthognathic surgery (COGS analysis) are the standard benchmark in cephalometrics for any orthognathic surgical diagnosis and treatment planning. Since the introduction of cephalometrics by Broadbent, numerous studies have been conducted to establish craniofacial norms of different ethnicities. Most of these studies, however, determined craniofacial norms for Caucasian people and may not be applicable to other ethnic groups due to differences in their facial appearance. Therefore, it is essential to study and compare the existing cephalometric parameters between Caucasians and Indians to validate their application during the treatment planning of the orthognathic surgery. This review focuses on studying the cephalometric norms for the North Indian (NI) population and establishing the COGS analysis for the population of North India. The objective is to determine the cephalometric parameters of Angle’s dental and skeletal Class I faces for the NI population. The following databases were searched for the present study - PubMed, Ovid MEDLINE, and EMBASE. The initial inclusion criteria comprised studies written in English and quoting cephalometric norms in Indian population. The time period of publications was not determined. The quality features evaluated were sample description, variables analyzed, and how cephalometric standards were evaluated. Initially, 49 articles were retrieved. After removal of the duplicated records and assessing for the eligibility, four articles met the inclusion criteria. These four articles were included in the systematic review. The NI people are characterized by having small cranial base, short facial height, protrusive chin, and more inclination of mandibular incisors in comparison with Caucasians. Due to limited research on the Central Indian cephalometric norms, the Caucasian norms are still referred for the diagnosis and treatment planning of orthognathic surgery for NI population.

Keywords: Cephalometric norms, North Indian population, orthognathic surgery

INTRODUCTION

Broadbent was the first to introduce roentgenographic cephalometry to study craniofacial growth and development to assess treatment progress, prognosis, and growth prediction for an individual.[1] In the current era, facial esthetics is a major concern for the patients, and sometimes orthodontic treatment alone might be insufficient to achieve this. Such cases require a combination of fixed orthodontic treatment and orthognathic surgery in order to obtain a balanced dental occlusion (i.e., Angle’s Class I), as well as a harmonious relationship between jaw bones and soft tissues of face.[2‑4] Hence, a specialized cephalometric appraisal system, called cephalometrics for orthognathic surgery (COGS) was developed at Indiana University to achieve the facial symmetry and balanced dental occlusion in the treatment of orthognathic surgical cases.[4,5]

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The COGS system illustrates the horizontal and vertical orientation of facial bones by utilizing a constant coordinate system that includes various linear and angular measurements that are either parallel or perpendicular to the true horizontal plane. The COGS analysis is beneficial in a way that it is based on the landmarks that can be changed by various surgical procedures. The use of cephalometrics provides a comprehensive evaluation of face by identifying dental, skeletal, and soft-tissue components. It also provides clear understanding and communication among orthodontists, maxillofacial surgeons, and the patients.

The current cephalometric norms formed by Burstone and Legan are utilized in orthodontic treatments and orthognathic surgeries as they are an established evidence on the normal range of cephalometric measurements. These cephalometric parameters are based on Caucasian population. The dental practices in India conform to this guideline and therefore, have not established local/national cephalometric guidelines. The development of a local and contextual cephalometric guideline is imperative and serves crucial to the orthognathic surgical planning as the evidence suggests that the Indian population groups possess distinct cephalometric ranges when compared to Caucasian population groups.

At present, there is no sufficient evidence about the availability of the COGS norms for the North Indian (NI) population, therefore, this review is considered to provide a strong statistical support for establishing the cephalometric norms for the NI adults.

METHODS

The methods used for this systematic review is based on the Journal of the Royal Society of Medicine protocol authored by Khan et al. The following: [Table 1].

Stage 1: Develop research question

This review article uses population-comparator-outcome mnemonic of PICOS (population-intervention-comparator-output-study design) protocol based on the systematic review protocol published by Centre for Reviews and Dissemination to construct the research question which forms the primary outcome (1°).

"What Cephalometric norms are suitable for the people (residents) of North India who require orthognathic surgery?"

Reading and becoming familiar with the articles and consulting with other researchers in the group (stakeholders) led to additional subquestions forming the secondary outcomes (2°):

1. What are the standard cephalometric norms (COGS analysis) used in orthognathic surgery?
2. These cephalometric norms belonged to which ethnic group?
3. Are these cephalometric norms applicable to Indian population?
4. What are the suitable COGS analysis forms for NI population?

Contents of the “PICOS” are provided in Table 2 which allows for a broad approach to answering the questions.

Stage 2: Identify relevant work

A preliminary search was done on PubMed/Medline databases to identify the relevant keywords and subject headings. To ensure that the research would encompass all the studies related to the topic, the following keywords were used: Cephalometric norms, COGS System, Indian population, orthognathic surgery, soft-tissue profile analysis, hard tissue profile analysis, review, and NI population. Thereafter, the following different electronic databases were searched for relevant publications:

- Cochrane library
- PubMed
- Ovid MEDLINE
- Ovid EMBASE

Table 1: The summary of the methods

| Stage | Name                        |
|-------|-----------------------------|
| 1     | Develop questions for a review |
| 2     | Identify relevant work      |
| 3     | Assessing the quality of studies |
| 4     | Summarizing the evidence    |
| 5     | Interpreting the findings   |

Table 2: The contents of the “Population-Intervention-Comparator-Outcome-Study Design” with inclusion and exclusion criteria

| PICOS                  | Inclusion                                                                 | Exclusion                                                                                   |
|------------------------|---------------------------------------------------------------------------|--------------------------------------------------------------------------------------------|
| Population             | The people of the North India, between 18-25 years of age.                | The people from other regions of India (East, West, and South India). The people below the age of 18 years and above the age of 25 years |
|                        | The minimum age considered was 18 years to assure the complete development of dental and skeletal tissues |                                                                                              |
| Comparator/ control    | The cephalometric norms for the Caucasian people, as most of the research have been done using cephalometric norms given by Burstone and Legan | The cephalometric norms for the people from other Asian and European countries               |
| Outcome                | Cephalometric norms for the North Indian population                       |                                                                                              |

PICOS: Population-intervention-comparator-output-study design
Cochrane database was investigated for a systematic review on the subject of the research and no data was found.

Inclusion/exclusion criteria served as a guide to identify the relevant and eligible articles for the systematic review. The eligibility criteria were structured in accordance with “PICOS” format. Table 2 shows the contents of the “PICOS” with inclusion and exclusion criteria.

To identify the potential articles, the initial search was performed by title and abstract. The initial inclusion criteria were studies in English language and quoting cephalometric norms and/or facial attractiveness in Indian adults. There was no limitation on the year of publication of studies.

Stage 3: Quality assessment of studies

Selection process

The selection process was independently conducted by two researchers. All articles were screened through title and abstracts. The inter-examiner conflicts were solved by discussion on each article, so as to reach a consensus regarding which articles fulfilled the selection criteria. The ultimately selected articles were then classified based on the following quality features: sample description, description of the analyzed variables, and the description of how the cephalometric standards or facial profiles were evaluated.

Sample description was considered adequate when the author clearly established the evaluated sample. The inclusion criteria were: adult Indians within the age range of 18–25 years of age, normal occlusion (Angle’s Class I) with minor or no crowding, all teeth present except third molars, no history of trauma, no previous orthodontic treatment, no previous orthognathic surgery, and no prosthetic replacement of teeth.

The minimum age of the sample was 18 years to ensure the complete growth of the dental and skeletal tissues, so that variability due to the growth could be avoided.

The analyzed variables were adequate when the articles showed which angular and linear variables were evaluated and from which cephalometric analysis they were from.

Stage 4: Summarizing the evidence

Results are presented in the Tables 3-6 and Appendix 1.

Figure 1 shows the flow of information of screening of the articles for the review.
Table 3 shows the cephalometric analyses used and the ethnic groups compared.

Table 4 illustrates the inclusion criteria for the selected studies and parameters used.

Tables 5 and 6 depict the data extracted from the articles and separated according to the gender and grouped according to skeletal or dental relationships as well as soft-tissue analysis.

**Stage 5: Interpreting the findings**

The data were collected and collated into excel sheet. The findings were tabulated separately as shown in the Appendix 1 and interpreted according to the bar graphs as shown in the results.

**RESULTS**

The following differences in the cephalometric parameters were found between the NIs and the Caucasians:

1. In anteroposterior dimension: The NI males showed shorter posterior cranial base as compared to the Caucasian males,[4,6] while the NI females showed greater anterior cranial base as compared to the Caucasian females.[9] Both the NI males and females showed prognathic maxilla and mandible, more protrusive chin, and more inclined mandibular incisors[4,6,9][Graph 1

| Article                  | Sample size | Male | Female | Age (years) | Lateral cephalograms | Photographs | History of Orthodontic or Orthognathic Surgery | Occlusion Parameters |
|-------------------------|-------------|------|--------|-------------|----------------------|-------------|-----------------------------------------------|---------------------|
| Tikku et al.            | 354         | 150  | 154    | 18-25       | NHP                  | Frontal and right profile | No               | Angle’s Class I molar relationship bilaterally | 16 Linear           |
| Wahi and Gupta          | 60          | 30   | 30     | 18-25       | NHP                  | No           | No                                           | Angle’s Class I molar relationship bilaterally | 24 Hard tissues    |
| Gulati and Jain         | 100         | 50   | 50     | 21.5-24     | NHP                  | No           | No                                           | Angle’s Class I molar relationship bilaterally | 23 Hard tissues    |
| S P Singh et al         | 100         | 46   | 54     | 14-24       | NHP                  | No           | No                                           | Angle’s Class I molar relationship bilaterally | 24 Hard tissues    |

NHP: Natural head position

| Cephalometric Norms | Tikku et al., 2014 | Wahi and Gupta, 2018 | Gulati and Jain, 2011 | Singh et al., 2014 |
|---------------------|--------------------|-----------------------|-----------------------|---------------------|
| Posterior cranial base | Short              | Short                 | NS                    | Short               |
| Anterior cranial base | Short              | Short                 | Short                 | NS                  |
| Prognathic maxilla   | Yes                | Yes                   | NS                    | Retruded            |
| Prognathic mandible  | Yes                | Yes                   | NS                    | Retruded            |
| Protrusive chin      | Yes                | Yes                   | Yes                   | No (less chin depth) |
| Middle third facial height | Short            | Short                 | NS                    | Short               |
| Posterior maxillary dental height | D              | D                     | I                     | Short               |
| Proclined maxillary incisors | NS          | Yes                   | Infraerupted          | Yes                 |
| Proclined mandibular incisors | NS        | Yes                   | Infraerupted          | Yes                 |

NS: Nonsignificant, D: Decreased, I: Increased

| Cephalometric Norms | Tikku et al., 2014 | Wahi and Gupta, 2018 | Gulati and Jain, 2011 | Singh et al., 2014 |
|---------------------|--------------------|-----------------------|-----------------------|---------------------|
| Posterior cranial base | Short              | NS                    | NS                    | NS                  |
| Anterior cranial base | Short              | Long                  | Long                  | Long                |
| Prognathic maxilla   | Y                  | Y                     | More Prognathic        | Retruded            |
| Prognathic mandible  | Y                  | Y                     | More Prognathic        | Retruded            |
| Protrusive chin      | Y                  | Y                     | Y                     | No (less chin depth) |
| Middle third facial height | Short            | Short                 | I                     | Short               |
| Posterior maxillary dental height | D              | D                     | I                     | Short               |
| Proclined maxillary incisors | NS          | Y                     | Infra-erupted          | Y                   |
| Proclined mandibular incisors | Y          | Y                     | Infra-erupted          | Y                   |

NS: Nonsignificant, D: Decreased, I: Increased
2. In the vertical dimension: The NIs showed decreased middle third facial height as well as decreased ramal and corpus length in comparison with the Caucasians\(^\text{[4,6,9]}\).

3. Sexual dimorphism: Noted for few vertical skeletal parameters among the NIs and were significantly greater in males than females\(^\text{[4,6,9]}\).

4. Only one study by Gupta and Wahi discussed the soft-tissue parameters and found that vertical height ratio, vertical chin-lip ratio, and the inter-labial gap is smaller while depth of the mentolabial sulcus is deeper in Haryana (NI) population than the Caucasians.\(^\text{[6]}\)

**DISCUSSION**

A combination of fixed orthodontic therapy and orthognathic surgery is required to achieve harmonious dental, skeletal (hard tissue) as well as soft-tissue relationships. Thus a specialized system, COGS was developed.\(^\text{[5]}\) The COGS describes the horizontal and vertical position of facial bones by various linear and angular parameters.\(^\text{[4,5]}\)

From the previous studies, it was evident that most of these cephalometric norms are based on the Caucasian population and could not be applied to other ethnic groups,\(^\text{[4]}\) hence, the current review was carried out to identify and establish the cephalometric norms for NI population.

The retrieved studies compared a group of adults (males and females) from the North India to the Caucasians in order to determine the differences in skeletal relationship, dental relationship, and the soft-tissue analysis. The significant differences in some of the hard and soft-tissue parameters were found between the NIs and the Caucasians.

**Skeletal (Hard) tissue parameters**

**North Indian males**

The studies by Tikku et al. and Gupta and Wahi analyzed that the NI males had smaller cranial base length, prognathic maxilla and mandible, more anteriorly placed chin position, decreased middle third facial height, and reduced maxillary and mandibular dental heights than the Caucasian males.\(^\text{[4,6]}\)

The proclination of the mandibular incisors was not significant in the study conducted by Tikku et al.,\(^\text{[4]}\) whereas in other studies, by Gupta and Wahi and Singh et al. mandibular incisors are more proclined in the NI males as compared to the Caucasian males,\(^\text{[6,8]}\) while according to Gulati and Jain, the maxillary and mandibular incisors are infraerupted in the NI males [Graph 2].\(^\text{[9]}\)

**North Indian females**

According to Tikku et al., the NI females had smaller posterior cranial base,\(^\text{[4]}\) while another researchers showed that the cranial base length posteriorly was nonsignificant in the NI females as compared to the Caucasian females.\(^\text{[6,9]}\) Moreover, Singh et al. stated that the posterior cranial base length was significantly more in the NI females than the Caucasian females [Graph 3].\(^\text{[8]}\)

Two articles by Gulati and Jain and Singh et al. published that the NI females had longer anterior cranial base than the Caucasian females.\(^\text{[8,9]}\) They also stated that the NI females presented more prognathic maxilla and mandible, and greater prominence of chin as compared to the Caucasian females.

Gupta and Wahi and Tikku et al. illustrated that the NI females had decreased middle third facial height as well as more proclined mandibular incisors than the Caucasian females.\(^\text{[4,6]}\)

However, Gulati and Jain presented increased middle third facial height and infra – erupt mandibular incisors in the NIs females than the Caucasian females.\(^\text{[9]}\)
Sexual dimorphism

Sexual dimorphism was evident for few vertical skeletal parameters as stated in the studies conducted by Tikku et al. and Gupta and Wahi.\[^{4,6}\] However, the difference in the findings was seen among these studies while interpreting the difference between the NI males and females [Graph 4]. According to the studies by Tikku et al. and Gupta and Wahi, the NI males displayed larger cranial base length, higher mid-third facial height, posterior maxillary height, greater anterior and posterior mandibular dental height, longer ramal, and corpus length in comparison with the NI females.\[^{4,6}\] On the other hand, Gulati and Jain stated that the NI females indicated increased anterior cranial base length, increased middle third facial height, and increased mandibular body length, infraerupted, and proclined lower incisors than the NI males. There was no evidence of sexual dimorphism for the dental parameters found in the research studies [Graph 5].\[^{9}\]

Soft-tissue parameters

Only one article by Gupta and Wahi compared the soft-tissue measurements between the NI population and Caucasians.\[^{6}\]

North Indian males and females

The soft-tissue analysis demonstrated that Haryana (NI) population has decreased vertical height and vertical chin-lip ratio, an increased lower vertical height to depth ratio, an obtuse lower face throat angle, deeper mentolabial sulcus, and shorter inter labial distance as compared to the Caucasians.\[^{6}\]

Disproportion in the vertical height ratio requires further measurement of the lower third of the face, i.e., the vertical lip-chin ratio.\[^{12}\] The study by Gupta and Wahi demonstrated that the vertical height of the chin compared to the upper lip length in the Haryana (NI) population is comparatively greater than in the Caucasians,\[^{6}\] while studies by Jain and Kalra and Mittal et al. described no significant difference in lip-chin ratio between the NIs and Caucasians.\[^{6,13,14}\]

Limitations

Study selection

Limited number of published studies was generated through the search strategy used in the databases.

Search error

Low number of relevant articles can be due to inappropriate and incomplete search strategy. Example: may have not considered other criteria, inadequate use of keywords.

Selection bias

Year of the publication might be limited, therefore, only four studies between the years 2011 and 2018 were generated. The excluded studies could have been valuable concerning other ethnic groups and the Asian countries. However, these studies did not fit the criteria and would have introduced more bias.

Systemic bias

Standardization of cephalometric norms may differ according to the phenotypes of people of different ethnicity. Hence, very few studies were related to the population of the interest. Example: more studies including cephalometric norms for the Caucasians were available as compared to Indian population.
Data extraction

Bias

One reviewer extracted and analyzed the data which may have introduced selection bias of introduced studies.

Data analysis

It was plausible that some findings and themes might have been missed from the included articles, as only those findings were discussed which had comparable data.

CONCLUSION

The skeletal (or hard tissue) and dental cephalometric dimensions were greater in the Caucasians as compared to the NI people with increased cranial base length and mid facial height, retruded chin, and retrognathic maxilla and mandible, whereas, the NI females exhibited more proclined mandibular incisors than the Caucasian females.

The sexual dimorphism in the NI population was evident which may help to assess the facial and dental deformity and plan surgical procedures more appropriately.

Only one study showed the soft-tissue analysis, depicting the NI population with decreased vertical height and vertical chin-lip ratio, deeper mentolabial sulcus, and shorter interlabial distance as compared to Caucasians.

Although there were significant differences in hard tissue and dental parameters between the Caucasians and the Indians, COGS analysis established by Burstone and Legan helped to define cephalometric norms for the NI population. This would help us to establish the COGS analyses for the NI population.

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Conflicts of interest

There are no conflicts of interest.

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APPENDIX

COGS – Cephalometrics for orthognathic surgery
PICOS – Population-Intervention-Comparator-Output-Study Design.
NI – North Indian