

# The applicability of centrographic analysis in pleasing craniofacial phenotypes

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## Abstract

**Context:** There has always been a need for nonnumeric facial analyses that would not compare an individual's facial measurements with the preestablished norms, rather evaluate the facial form individually. This would help in diagnosis and treatment planning, unique to that individual. **Aims:** The purpose of the study was to determine and establish a relation between skeletal, dental and soft tissue structures using centrographic analysis (CGA) in pleasing faces of Western Uttar Pradesh population. **Materials and Methods:** A total of 50 subjects (22 males and 28 females) with "most pleasing faces" were taken up for the study, within the age group of 20-25 years. Frontal facial photographs and lateral cephalograms were taken for all the subjects. Conventional cephalometric analysis and CGA were applied to each lateral cephalogram. Arithmetic mean and standard deviation values were calculated, and an independent *t*-test was performed for calculating cephalomorphic norms and comparison between the male and female sample. **Results:** The results showed that, the adults in the age group of 20-25 years, belonging to the Western Uttar Pradesh population have protrusive maxillary and mandibular skeletal bases and retrusive upper lip on contrary to a protrusive lower lip, though a sexual dimorphism was observed. The upper centroid and lower centroid values were statistically greater in women ( $P = 0.05$  and  $P = 0.04$  respectively) whereas, upper lip linear value was statistically greater in men. **Conclusions:** The CGA is valid for Western Uttar Pradesh population. The Western Uttar Pradesh adults have protrusive mandible and a retrusive upper lip though there exists a sexual dimorphism. These practical centrographic norms can be used as an adjunct to the conventional cephalometric evaluation of an individual for diagnosis and treatment planning.

**Key words:** Centrographic analysis, centroid, facial form

## INTRODUCTION

As greatly said by Gary Martin, the experience of "beauty" often involves an interpretation of some entity as being in balance and harmony with nature, which may lead to feelings of attraction and emotional well-being. Because

this can be a subjective experience, it is often said that "beauty is in the eye of the beholder."<sup>[1]</sup>

A prime role has been played by the conventional cephalometric analyses in the evaluation of the facial forms, the majority of which have used methods that numerically compare a finding with the preestablished norm. Though this methodology has been widely accepted and used, it is not a rational method especially for clinical diagnosis as each individual exhibited his or her own unique pattern of craniofacial development. Hence, morphologic homogeneity within the preestablished norms may not exist. Therefore, the concept of comparing such norms numerically and its use for evaluating the individuals who do not demonstrate anatomic homogeneity may subject to inaccuracy.

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There has always been a need for nonnumeric facial analyses that would not compare an individual's facial measurements with the preestablished norms, rather evaluate the facial form individually. This would help in diagnosis and treatment planning, unique to that individual.

Numerous nonnumerical analyses have been proposed to eliminate the comparison of patients' values with preestablished norms. Investigators such as Decoster<sup>[2]</sup> and Moorrees and Le Bret,<sup>[3]</sup> have presented different facial analyses that focus on a nonnumerical morphologic evaluation of an individual.

It is important to mention the work of the English orthodontist Johnson. His investigations emphasize the application of centroids to the evaluation of cranial and facial structures. Recognizing the stability of centroids relative to traditional cephalometric landmarks during the growth period, he described morphologic changes particularly within the cranium.<sup>[4-7]</sup> In 1997, Leonard S. Fishman worked further on the principles developed by Johnson and stated that the centrographic analysis (CGA) is unique to each patient. It cephalomorphically demonstrates vertical and horizontal balance or disharmony in skeletal, dental, and soft-tissue form and position. The facial centroid (FC) axis provides a relatively stable reference plane that can be used for longitudinal cephalomorphic superimposition.<sup>[8]</sup>

Based on the principles of centroid orientation, the CGA demonstrates the vertical and horizontal balance and disharmony in skeletal and soft tissue form and position.<sup>[4]</sup> This analysis also provides the orthodontist with an individualized approach to cephalomorphic evaluation.

Hence, the purpose of this study was to determine and establish a relation between skeletal, dental and soft tissue structures using CGA, in pleasing faces of Western Uttar Pradesh population with the following objectives:

- To validate the CGA in the "pleasing faces."
- To identify for any possible difference, in relation to gender variation.
- To establish a co-relation between skeletal, dental and soft tissue compensations, if present, in determining facial balance.

## SUBJECTS AND METHODS

A total of 50 subjects (22 males and 28 females) with "most pleasing faces," within the age group of 20-25 years were taken up for the study. Digital soft and hard copies of the frontal facial photographs and lateral cephalograms were taken for each selected sample. A written consent was taken

from all the subjects as prescribed and approved by the Ethical Committee at the Subharti Dental College.

### Inclusion criteria

1. North Indian origin.
2. Age group 20-25 years.
3. Full complement of permanent teeth with acceptable occlusion.

### Exclusion criteria

1. Any congenital facial defects.
2. History of orthodontic treatment or facial surgery.
3. Congenitally missing teeth or extracted teeth, except third molars.
4. Developmental anomaly of any part of the body.
5. History of systemic disease or hospitalization in last 3 years.

### Armamentarium

Digital single lens reflex camera (Canon EOS 20 D) with an aperture of f/8 and shutter speed f 1/100 s, a 100 mm macro lens (Canon EF 100 mm) duly fitted on the camera, photography room with a white background and umbrella lights, an adjustable tripod to stabilize the camera, a metallic ruler with an adjustable sling, frontal view photographs of the subjects, lateral cephalograms of all the subjects, with the help of digital cephalometric X-ray system (Pax-400C, VATECH, value added Technologies, Korea). Cephalograms obtained were manually traced on a lacquered polyester acetate paper using a 3H lead pencil, tracing table with 14 W compact fluorescent lamp, 12 mm metallic ruler, set squares and a protractor.

### Method

This was an observational cross-sectional study. North Indian subjects were screened to be taken up for the study. A total of 216 subjects (103 males and 113 females), meeting the selection criteria were evaluated further, to finally select a total of 50 subjects with "most pleasing faces" (22 males and 28 females), within the age group of 20-25 years.

To finalize the sample, a panel of 20 people from the esthetic and cosmetic industry (4 orthodontist, 3 dentists, 2 beautician, 3 professional photographers, 4 fashion designers, 4 fine art professionals) were chosen to evaluate the subjects for their facial attractiveness. Each member of the panel was asked to rate the frontal facial photographs of all the 216 samples and give them a score from 1 to 3. Each panel member was given a rater number as R1, R2, R3.....to R20 to score males and females separately. Scores from all the individual raters ( $n = 20$ ) for each sample were added. A final score ranging from a minimum score of 20 to a maximum score of 60 was possible for each

sample. After these subjective assessments, the subject photographs were divided into three groups:

1. Most pleasing faces.
2. Pleasing faces.
3. Average pleasing faces.

For the study, only “most pleasing faces” were considered. Lateral cephalograms of the selected sample (22 males and 28 females) were taken in Natural head position.

To determine the errors associated with radiographic measurements, 15 radiographs were selected randomly. Their tracings and measurements were repeated 8 weeks after the first measurement. A paired sample *t*-test was applied to the first and second measurements. It was found that the difference between the first and second measurements of the 20 radiographs was insignificant.

The various parameters for conventional cephalometric analysis and the CGA used were:

### Conventional cephalometric analysis

1. Skeletal angular measurements
  - a. ANB angle: Angle between the NA and NB lines.<sup>[5]</sup>
  - b. Mandibular plane angle (Sella-nasion-gonion gnathion [SN-GoGn]): Angle between the SN plane and the mandibular plane (GoGn).<sup>[6]</sup>
  - c. Frankfurt mandibular angle (FMA): Angle between the Po-Or line and the mandibular plane.<sup>[7]</sup>
2. Dental linear measurements
  - a. Maxillary incisor to NA plane (U1-NA): Horizontal distance between the tip of the upper incisor and a line from N to point A.<sup>[7]</sup>
  - b. Mandibular incisor to NB (L1-NB): Horizontal distance between the tip of the mandibular incisor and a line from the nasion to point B.<sup>[6]</sup>
3. Soft tissue linear measurements
  - a. Upper lip protrusion (Ls to Sn-Pg'): Distance between labrale superius to subnasale-soft tissue pogonion.<sup>[8]</sup>
  - b. Lower lip protrusion (Li to Sn-Pg'): Distance between labrale inferius to subnasale-soft tissue pogonion.<sup>[8]</sup>
  - c. Upper lip thickness: Linear distance between the vermillion border of the upper lip to the labial surface of the upper incisor.<sup>[9]</sup>
  - d. Lower lip thickness: Linear distance between the vermillion border of the lower lip to the labial surface of the lower incisor.<sup>[9]</sup>

### The centrographic analysis

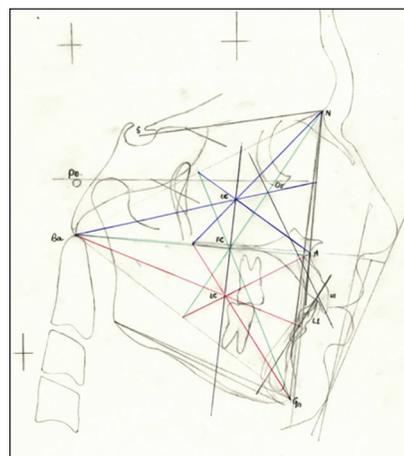
The centroid analysis was done as described by Fishman.<sup>[8]</sup> Only five points (S, N, Ba, A, and Pog) and four lines (S-Na, Na-Ba, Ba-A, and Ba-Gn) were drawn on the X-ray

tracings for analysis. This analysis establishes the location of centroids within the following three anatomically determined triangular areas:

- Facial centroid: Triangle (Ba-Na-Gn), total face [Figure 1].
- Upper centroid (UC): Triangle (Ba-Na-A), upper face [Figure 1].
- Lower centroid (LC): Triangle (Ba-A-Gn), lower face [Figure 1].

The centroid of each triangle is determined centrographically by drawing a line from the vertex of the respective triangle and bisecting the opposite leg of the triangle. This is done at a second vertex to the opposite leg. The intersection of these two lines determines the centroid and serves as the point of reference for analysis in the sagittal aspect. This is done on all three triangles. The centroid plane is constructed as a perpendicular to Ba-A through the FC [Figure 1].

In the vertical plane, the subjects were categorized as deficient, excessive, or neutral based on the vertical position of FC to a line formed by Ba-point A. In persons with balanced vertical skeletal harmony, the FC is located directly on the Ba-A plane [0], the constructed division between the upper and lower faces.<sup>[4]</sup> In persons with a deficiency in the vertical development of the lower face, the FC is positioned within the upper face, which is denoted by a [+ ] sign. In persons with an excess in the vertical development of the lower face, the FC is positioned within the lower face, which is denoted with a [- ] sign. Horizontal skeletal imbalance is evaluated by assessing the anteroposterior positions of UC and LC to the centroid plane. For example, if UC is posterior to the centroid plane, the subject is maxillary retrognathic and is denoted with a [- ] value. If LC is anterior to the centroid plane, the subject is mandibular prognathic, which is denoted with a [+ ] value as done by Yagci *et al.*<sup>[14]</sup>



**Figure 1:** Centroid construction: Facial centroid, upper centroid and lower centroid. Centroid plane drawn from point A to basion

Soft-tissue pogonion to subnasale (inner profile) and soft-tissue pogonion to nasal tip (outer profile) planes are used together to evaluate the positional balance of the lips. A desirable relationship can be described as both lips being positioned relatively equal within the space between the two planes at rest position and in occlusion, with the upper lip being positioned more anteriorly than the lower lip.<sup>[9]</sup>

For this study, an angle bisector of the angle formed by subnasale-soft tissue pogonion-nasal tip was drawn and then upper and lower lip projections to bisector were measured [Figure 2]. Lip positioned anterior to the bisector line was valued with a [+] sign and a lip positioned posterior to the bisector line was valued with a [-] sign.<sup>[10]</sup>

The analysis was performed by a single observer to avoid the inter-observer error. The cephalometric parameters were compared, among males and females and statistical analysis done.

**Statistical analysis**

All statistical analyses were performed using the Statistical Package for Social Sciences (Windows, version 21.0, SPSS Inc, Chicago, IL, USA). Arithmetic mean and standard deviation values were calculated for each conventional and centrographic measurements. An independent samples *t*-test was performed for statistical evaluation of gender differences.

**RESULTS**

Combined cephalometric norms, means, and standard deviations for Western Uttar Pradesh males and females are shown in Tables 1 and 2, respectively. Descriptive statistics of the cephalomorphic norms of Western Uttar Pradesh adults are shown in Table 3. These centroid-based results showed that Western Uttar Pradesh adults have protrusive maxillary and mandibular skeletal bases and retrusive upper



**Figure 2:** Soft tissue evaluation

lip on contrary to a protrusive lower lip. The following results were obtained through the independent-samples *t*-test applied to compare the measurement differences between males and females with pleasing faces. Of the seven measurements, three showed statistically significant gender differences [Table 4]. The UC and LC values were statistically greater in women (*P* = 0.05 and *P* = 0.04 respectively) whereas upper lip linear value was statistically greater in men.

**Table 1: Combined cephalometric norms, means and SD for Western Uttar Pradesh pleasing faces — males**

Measurement	North Indian norms	Calculated values
		Mean ± SD
ANB (°)	3.02	1.84±2.3
FMA (MP-FH) (°)	23.49	20.4±5.2
SN-GoGn (°)	27.24	25.5±6.1
U1-NA (mm)	6.23	7.0±2.6
L1-NB (mm)	6.82	5.8±1.9
Upper lip protrusion (mm)	3.8±1.4	4.1±1.6
Lower lip protrusion (mm)	2±2.4	2.13±2.4
Upper lip thickness (mm)	17.2±1.8	16.1±1.9
Lower lip thickness (mm)	15.4±1.8	12.8±1.7

SD – Standard deviation; FMA – Frankfurt mandibular angle

**Table 2: Combined cephalometric norms, means and SD for Western Uttar Pradesh pleasing faces — females**

Measurement	North Indian norms	Calculated values
		Mean ± SD
ANB (°)	3.52	3.57±2.5
FMA (MP-FH) (°)	23.49	23.3±4.9
SN-GoGn (°)	26.83	30±5.1
U1-NA (mm)	5.65	6.8±2.5
L1-NB (mm)	6.02	6.4±2.2
Upper lip protrusion (mm)	3.4±1.0	3.75±1.4
Lower lip protrusion (mm)	2.7±2.06	2.35±2.0
Upper lip thickness (mm)	14.2±1.7	15.8±2.0
Lower lip thickness (mm)	13.4±1.5	13.2±2.6

SD – Standard deviation; FMA – Frankfurt mandibular angle

**Table 3: Descriptive statistics of the cephalomorphic norms of the Western Uttar Pradesh pleasing faces**

Measurement	Normative values	Calculated values
		Mean ± SD
FC (upper [+] lower [-])	0.0	-0.2±2.2
UC (upper [+] lower [-])	0.0	0.08±1.7
LC (upper [+] lower [-])	0.0	1.22±1.1
Upper lip (anterior [+] posterior [-])	0.0	-0.12±1.5
Lower lip (anterior [+] posterior [-])	0.0	0.35±1.8

SD – Standard deviation; FC – Facial centroid; UC – Upper centroid; LC – Lower centroid

**Table 4: Means and SD of cephalometric and centrographic measurements of pleasing males and females of Western Uttar Pradesh population**

Measurement	Mean±SD		t-test
	Males (n = 22)	Females (n = 28)	
FC (upper [+] lower [-]) (vertical)	0.3±2.2	-0.55±1.7	NS
UC (upper [+] lower [-]) (sagittal)	-0.7±1.8	0.68±1.5	0.005
LC (upper [+] lower [-]) (sagittal)	0.8±1.1	1.5±1.1	0.04
Upper incisor linear	7.0±2.6	6.8±2.5	0.03
Lower incisor linear	5.8±1.9	6.4±2.2	NS
Upper lip (anterior [+] posterior [-])	-0.1±1.6	-0.14±1.5	NS
Lower lip (anterior [+] posterior [-])	0.1±1.9	0.55±1.8	NS

SD – Standard deviation; FC – Facial centroid; UC – Upper centroid; LC – Lower centroid; NS – Not significant

## DISCUSSION

The subjects investigated in this study were untreated Western Uttar Pradesh adults with ideal occlusion and well-balanced faces. The selection criteria and methodology were oriented to identify normative values that can assist in the diagnosis and treatment planning for Western Uttar Pradesh adults. The data were separated according to the gender in order to obtain more specific and useful cephalometric normative values.

On evaluating the skeletal, dental and soft tissue pattern of individuals with CGA, following findings were observed [Table 3].

### The facial centroid

The mean and standard deviation for males and females with pleasing faces is  $-0.2 \pm 2.2$  mm, where the [-] sign indicates the location of FC in the lower face, nearer to the Ba-A plane. This depicted that the pleasing faces of both males and females exhibited more or less normodivergent or a mild hyperdivergent growth pattern.

### The upper centroid

The mean and standard deviation for males and females with pleasing faces is  $0.08 \pm 1.7$  mm, which signifies the location of UC anterior to the centroid plane. This depicted that the pleasing faces of both males and females exhibited a normally positioned or a mild protrusive maxilla.

### The lower centroid

The mean and standard deviation for males and females with pleasing faces is  $1.2 \pm 1.1$  mm, which signifies the location of LC anterior to the centroid plane. This depicted that that on an average the pleasing faces of both males and females exhibited a mild protrusive mandible.

### The upper lip

The mean and standard deviation for males and females with pleasing faces is  $-0.12 \pm 1.5$  mm, which depicted that the pleasing faces of both males and females possess a normally positioned or a mild retrusive upper lip.

### The lower lip

The mean and standard deviation for males and females with pleasing faces is  $0.35 \pm 1.8$  mm, which depicted that on an average the pleasing faces of both males and females exhibited a mild protrusive lower lip.

## Comparisons of attractive males-attractive females

### Assessment of the centrographic skeletal characteristics

On assessment of the centroids between pleasing females and pleasing males, it was observed that there was no statistically significant difference between the FCs ( $P = 0.15$ ) whereas a significant difference was present in between the upper and the LCs ( $P = 0.005$  and  $P = 0.04$  respectively).

### The vertical plane

In the vertical plane, the position of the FC was studied for evaluating vertical plane disharmony. A deficiency in the vertical development of the lower face is depicted by the FC being positioned within the upper face. An excessive amount of lower facial development is depicted by the FC being positioned within the lower face. In other words, when FC lies in the upper triangle, that is, above Ba-A plane, it shows the horizontal growth pattern and when it lies in lower triangle, that is, below Ba-A plane, it shows the vertical growth pattern.<sup>[18]</sup>

On statistical analysis, the mean for the FCs in pleasing males was calculated as  $0.3 \pm 2.2$  mm and for pleasing females it was  $-0.55 \pm 1.7$  mm. Though there exists a difference in the values but it is not statistically significant. The calculated values depicted that the pleasing males have their FC positioned in the upper face, while the pleasing females have their FC located in the lower face. This signifies that the clinically pleasing male profiles have a deficiency in vertical development of the lower face and have a horizontal or hypodivergent pattern of growth whereas pleasing females have an excess in vertical development of the lower face and have an average or mild hyperdivergent pattern of growth.

When same samples were assessed cephalometrically with angles SN-GoGn and FMA, it was observed that skeletal variation existed. On the cephalometric comparing position of FC with angle SN-GoGn and FMA the latter angles confirmed the horizontal or the hypodivergent growth pattern and the average or the normodivergent growth

pattern for the males and females with pleasing faces respectively.

### *The sagittal plane*

The sagittal relation of the UC (centroid of triangle Ba-Na-A that represents upper face) and LC (centroid of triangle Ba-A-Gn that represents lower face) with respect to centroid plane were evaluated.

In CGA for evaluating sagittal discrepancy, the relation of UC and LC with respect to centroid plane is seen. According to the analysis, the class I condition is said to be present where UC and LC coincide with the centroid plane. In this study, the possibility of UC and LC coinciding with centroid plane was observed to be minimum, even though, the study was conducted on esthetically pleasing individuals with the clinically well-balanced facial profile. These findings are in concurrence with the findings by Nehete and Hazare.<sup>[18]</sup>

Any deviation of UC or LC from the centroid plane determines the skeletal pattern as protrusive or retrusive maxilla or mandible accounting for an individual's skeletal pattern.<sup>[19,20]</sup>

The mean for the UCs in pleasing males was calculated as  $-0.7 \pm 1.8$  mm and for pleasing females it was  $0.68 \pm 1.5$  mm, which showed the statistically significant difference. ( $P = 0.005$ ). The UCs in pleasing males are found to be positioned mild posterior to the centroid plane, which depicted that these subjects exhibit a retrusive maxilla. Whereas, the UCs in pleasing females are found to be positioned mild anterior to the centroid plane, which depicted that these subjects exhibited a protrusive maxilla. Similarly, a significant difference was observed in the mean values for the LCs, which was  $0.8 \pm 1.1$  for pleasing males and  $1.5 \pm 1.1$  for pleasing females. The calculated value signifies that the pleasing males exhibited more or less normally positioned mandible, whereas the pleasing sample of females displayed a prognathic lower jaw. When the same sample was evaluated cephalometrically, variation was seen in angle ANB and it was observed that skeletal variation existed.

### *Assessment of the centrographic dental characteristics*

Morphologic relationships of dental balance and harmony describes a more protrusive upper incisor position with respect to A-Pog plane as it was calculated as  $7.82 \pm 1.7$  mm in pleasing females and  $6.5 \pm 2.4$  mm in pleasing males. The labial surface of the lower incisor is also placed in a more protrusive position in relation to A-Pog plane in pleasing females ( $3.67 \pm 2.0$  mm) than in pleasing males ( $2.9 \pm 2.3$  mm). Hence, the findings suggest that individuals

with well-balanced skeletal and soft-tissue profiles and normal occlusion when evaluated with CGA demonstrated protrusive upper and lower incisors.

These findings, when evaluated cephalometrically, using the Steiner's upper incisor to NA and lower incisor to NB linear measurement in pleasing males and females, suggests forwardly positioned upper and lower incisors.

### *Assessment of the centrographic soft tissue characteristics*

Linear distances were measured from the bisector of the inner and the outer profile plane to the most prominent point on the upper and the lower lips.

For pleasing males the value was calculated as  $-0.1 \pm 1.6$  mm and for pleasing females it was  $-0.1 \pm 1.5$  mm for the upper lip. On statistical analysis, there was no significant difference though the calculated values depict more or less normally positioned upper lip for both pleasing males and females. Similarly, for pleasing males the value was calculated as  $0.1 \pm 1.9$  mm and for pleasing females it was  $0.5 \pm 1.8$  mm for the lower lip. On statistical analysis, there was no significant difference. The calculated value signifies that the pleasing males exhibited more or less normally positioned lower lip, whereas the pleasing sample of females displayed a retrusive lower lip.

These findings when evaluated cephalometrically, using the upper and lower lip protrusion linear measurements as done by Burstone<sup>[12]</sup> suggests protrusive upper and lower lips in pleasing males and females. These values are in an agreement with the values given by Jitender Singh *et al.*,<sup>[17]</sup> which depicted a normally positioned upper lip for both males and females and a normally positioned lower lip in pleasing males on contrary to mild retrusive lower lip in pleasing females.

### *Co-relation between skeletal, dental and soft tissue structures in a pleasing face*

On evaluation of the selected sample of clinically pleasing males using the CGA, the pleasing males exhibited a retrusive maxillary skeletal base. The dental protrusion was seen in order to compensate for the skeletal defect. In order to curtain the skeletal and dental mal-relationship the soft tissue, that is, the upper lip thickness was reduced. Furthermore, the pleasing males displayed a protrusive mandibular skeletal base with no compensations occurring at the dento-alveolar structures. In turn, the compensations occurred at the soft tissue, with a noticeable increase in lower lip thickness.

On the contrary, the pleasing females exhibited a protrusive maxillary base with no compensations at

the dento-alveolar and soft tissue structures. Also, the mandibular skeletal base was found to be protrusive with no compensation at the dento-alveolar structures leading to their forward positioning with a mild compensation occurring at the soft tissue structures with a reduction in lower lip thickness.

## CONCLUSION

Fishman's CGA is based on a nonnumeric evaluation of an individual. In the present study, a numeric approach was made. The following conclusions can be drawn from the study:

1. The CGA is valid for Western Uttar Pradesh population.
2. The Western Uttar Pradesh adults have protrusive mandible and a retrusive upper lip though there exists a sexual dimorphism.
3. The study gives cephalomorphic norms for Western Uttar Pradesh population.

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