Original Article

Establishing cephalometric norms for a Mexican population using Ricketts, Steiner, Tweed and Arnett analyses

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Abstract

Objective: Most existing cephalometric analyses are based on norms for the Caucasian population. Therefore, they cannot be properly applied for Latin-American (Hispanic) patients. It is the purpose of this study to establish specific cephalometric standards for a Mexican ethnic group, using the Ricketts, Steiner, Tweed and Arnett analyses. **Materials and Methods:** Lateral cephalograms of 100 non-growing patients which consists of 50 females and 50 males with native Mexican features and born in the central regions of Mexico, were traced manually and with the Quick Ceph Image Pro™ computer program. Lateral cephalograms of another subset of 30 patients with pleasant profiles (19 females and 11 males) were traced and Arnett Facial Analysis was performed. Results were statistically analyzed with the *t*-value, *P* value ($P < 0.01$) and the 95% of the confidence statistic interval for a population mean was applied for each cephalometric measurement and norm. **Results:** The statistical results of these cephalometric norms for a Hispanic population showed significant differences in the upper and lower incisors, facial axis and interincisal angles as well as other cephalometric measurements when compared to the Caucasian norms. **Conclusion:** These cephalometric norms can be applied for Native Americans from the USA and Latin-Americans from Central and South American countries due to the strong anthropometric, facial and ethnic similarities to the Mexican population.

Key words: Cephalometric norms, Mexican population, Ricketts' analysis, Steiner's analysis, Tweed's analysis, Arnett Facial Analysis

INTRODUCTION

Moyers[1] stated that when cephalometric measures are derived from research populations, one should know the nature of that population and the variability of the measure because many measures commonly used show marked changes in value during growth and significant differences between the sexes and among various ethnic groups.

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Canavati,[2] in 1967 studied 60 Latin-American children of 4 and 5 years of age and concluded that this group of children presented a higher incidence of dental protrusion when compared with Caucasian children. Kennedy,[3] in 1969 examined cephalometric measurements of Latin-American children ranging in age from 4 to 8 years and found similar results as in Canavati's study. Velarde,[4] in 1974 analyzed 31 males and 9 females of Latin-American origin from Chihuahua, Mexico using the Ricketts, Steiner and Tweed analyses. He concluded that the Latin-American group had a slightly more protrusive dental pattern than the Caucasian norms and that the skeletal pattern had a tendency toward prognathism of the maxilla and mandible. Garcia,[5] in 1975, evaluated cephalograms of 59 Mexican-American children using the Downs, Steiner and Alabama analyses. He concluded that the Mexican-American group had a more prognathic skeletal pattern as well as a more protrusive

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dental relationship when compared to the Caucasian norms. Bishara and Fernandez,[6] in 1985 performed cephalometric comparisons between two adolescent populations from Iowa and Northern Mexico. They concluded that the most significant differences between the Northern Mexican girls and the Iowa girls were the SNB and SN-Pog angles, as well as, the ratio of the posterior face height, which was seen to be larger in the Northern Mexican girls. Swlerenga *et al.*,[7] in 1994, analyzed a group of 48 Mexican-American patients with parents or grandparents born in Mexico, from three USA Air Force dental clinics to evaluate cephalometric differences between them and a Caucasian group. They concluded that skeletally, Mexican-American males had longer maxillary and mandibular lengths with a flatter mandibular plane than the Caucasian males. Dentally, both Mexican-American men and women exhibited more protrusive lower incisors than Caucasians.

Our main concerns and observations are that none of the previous studies used the homogeneity and purity of a Native-Mexican ethnic population and most of these studies used a children population, therefore, growth was a variable poorly addressed considering the fact that craniofacial ethnic features are fully developed after growth completion.[8]

The most important and rich cultures of the Native Mexican ethnic groups (Aztecs and Mayas) before the Spanish conquest in 1519, were developed in the central and Southeastern regions of Mexico.[9] It was determined in this study to examine a group of people with the smallest racial mixture by addressing and analyzing a population with all the facial and anthropometric ethnic features of the native Mexican Indians in a central Mexican community.

The Arnett Facial Analysis (AFA),[10,11] developed in 1993 by Dr. William Arnett utilizes the true vertical line (TVL) as a reference from which the hard and soft-tissues are measured. The norms in the AFA were taken from a group of 40 Caucasian males and females with pleasant faces, in which most were fashion models. The use of the AFA in this study will result in establishing the facial aesthetic norms and features in combination with normal occlusions for a Mexican ethnic group.

The use of computerized cephalometric programs has helped orthodontists to achieve efficiency in the tracings for visual treatment objectives (VTOs) and surgical treatment objective (STOs). Ricketts[12] established cephalometric norms utilizing a computer program developed by Rocky Mountain Data Systems[13] In 1986, Blaseio[14] developed the Quick Ceph Image Pro™ computer program to calculate the measurements of several cephalometric analyses by tracing cephalometric landmarks into the computer.

The purpose of this study was to establish specific cephalometric norms for a pure Mexican ethnic group using the Ricketts,[15-17] Steiner[18] and Tweed[19] analyses along with the AFA.[10,11]

MATERIALS AND METHODS

Full orthodontic records (X-rays, photographs and models) of 856 patients, with at least four generations of their family background (parents) belonging to a native Mexican Indian ethnic group of the central and southeastern regions of Mexico were collected and sent to Loma Linda University. From these 856 original patients, 50 females and 50 males were selected. The criteria for selection of these patients were as follows:

Untreated Class I molar and cuspid occlusion, full permanent dentition, less than 3 mm of arch length discrepancy, normal overbite and overjet. All these patients were non-growing females, ages ranging from 14 to 25 years and males with an age range of 18-35 years of age. They all presented anthropometric and ethnic features of the native Mexicans born in central and southeastern Mexico.

The lateral cephalograms of the selected patients were hand and computer traced by one investigator and then checked for accuracy by three other investigators. A scriptel glass screen digitizer was used to trace the landmarks and minimize the standardization error. By capturing the data of the lateral cephalograms into a Power Macintosh 7500/100 computer, the Quick Ceph Image Pro™ cephalometric program was used to obtain the measurements and norms for the Ricketts,[15-17] Steiner[18] and Tweed[19] analyses. From this group of 100 patients, another subset of 30 patients (11 males and 19 females) with harmonious and well balanced profiles was selected and their lateral cephalograms were digitally traced. All subjects presented with Mexican native and ethnic features such as skin color, average height (< 1.65 m), tooth shape, straight hair and no beard. The purpose of this part of the study was to establish skeletal, facial and soft-tissue norms for a Mexican population and compare them with Caucasian norms of the AFA.[10,11]

The results were divided into three groups: Group 1, formed by 50 males; Group 2, formed by 50 females and Group 3, formed by 30 patients (11 males and 19 females) with harmonious profiles. The Mexican and Caucasian cephalometric and facial norms were compared to emphasize the main differences between them. The mean age for the Mexican males was 21 years and for the Mexican females was 17 years. The mean average age of the subset group for the AFA was 19 years. The three groups were statistically tested with the independent

t-test and the analysis of variance for each cephalometric measurement. The *t*-value, *P* value ($P < 0.01$), as well as the 95% confidence interval for a population mean was applied.

The results for the Mexican male and female cephalometric norms and standard deviations for the Ricketts, Steiner and Tweed analyses of this native Mexican population were established and are documented in Tables 1 and 2 respectively. The cephalometric norms of the native Mexicans for the AFA were established and compared with the Caucasian norms and are documented in Table 3.

The most significant statistical differences between the Caucasian and Mexican norms are emphasized with an asterisk at the end of each column in Tables 1-3. The two composite cephalometric tracings with the most statistically significant differences for the Ricketts, Steiner and Tweed analyses of the Mexican male and female norms are represented in Figures 1 and 2. Figure 3 represents the final composite tracing for a Mexican adult profile with the norms for the AFA.

RESULTS

The *P* value for significance used for this study was set at $P < 0.01$, which means that the differences were "statistically significant." After comparing data from the three groups, measurements meeting this *P* value were marked with an asterisk in Tables 1-3.

Ricketts analysis results

Cranial relations

Mexican males and females showed a more obtuse posterior face and greater maxillary height than their Caucasian counterparts. Having a more acute angle in the ramus position, facial depth and facial taper is lesser than Caucasians.

The Mexican males presented a longer Porion location with a more obtuse mandibular plane. The Mexican females showed a more obtuse palatal plane angle and a shorter maxillary depth than Caucasian females.

Maxilla/mandible relations

Both Mexican males and females presented a greater facial convexity and lower face height which was statistically higher than Caucasians. The mandibular arc in the Mexican females was statistically greater when compared with the Caucasian females.

Dental relations

The maxillary and mandibular incisors in both Mexican males and females are statistically more protrusive than Caucasians. The mandibular incisor inclination values showed that the lower incisors were more procumbent and protrusive in Mexican males and females. The lower incisor extrusion in relation to the occlusal plane was statistically lower in both Mexican men and women when compared

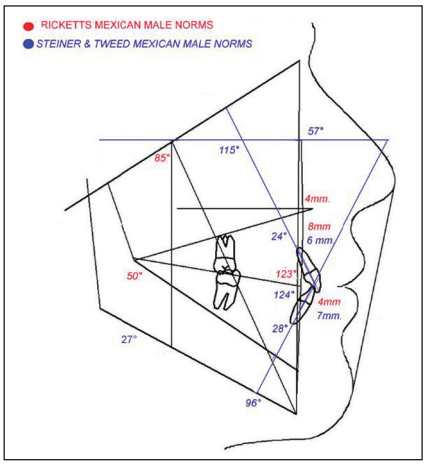

Figure 1: Composite tracing of the Mexican male norms showing the most significant statistical differences for the Ricketts, Steiner and Tweed analyses

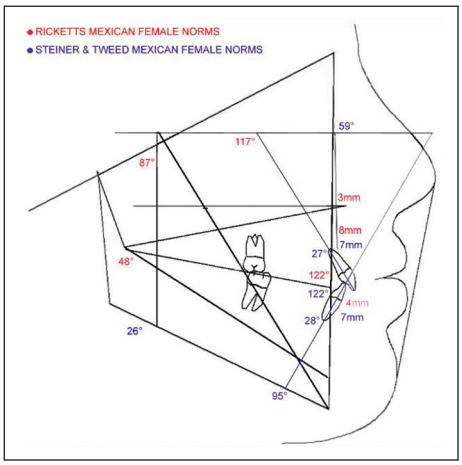

Figure 2: Composite tracing of the Mexican female norms showing the most significant statistical differences for the Ricketts, Steiner and Tweed analyses

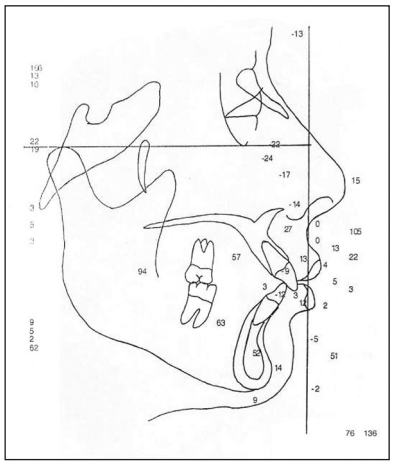

Figure 3: Composite tracing of a Mexican population norms showing significant statistical differences for the Arnett Analysis

Table 1: Comparison of cephalometric norms between Caucasian and a Mexican male group for the Ricketts, Steiner and Tweed analyses, mean age = 21 years, *N* = 50

Cranial relations	Caucasian	Mexican	±SD
Ricketts analysis			
Ant cranial base (mm)	62.6	60	2
Post-facial height (mm)	54.8	74.1	3
Cranial deflect (dg)	27.3	29.3	3
Porion location (mm)	−38.6	−42.8	2*
Ramus position (dg)	76	73.9	3*
Mx position			
Maxillary depth (dg)	90	90.3	3
Maxillary height (dg)	56.8	60.4	3*
SN-palatinal plane (dg)	7.3	7.3	3
Md position			
Facial depth (dg)	89.6	87	3*
Facial axis (dg)	90	85.6	3*
Mandibular plane (dg)	26	27	4*
Total facial height (dg)	60	63	3*
Facial taper (dg)	68	66.6	3*
Maxilla/mandible relations			
Convexity (mm)	0.1	3.6	2*
Corpus length (mm)	80.2	76.6	4*
Mandibular arc (dg)	31.8	33.8	4
Lower facial height (dg)	47 h	49.5	4*
Denture relations			
Mx dentition			
Mx 1, to Apo (mm)	3.5	8.1	2*
Mx 1, to FH (dg)	111	115.6	5
Mx 6, to PTV (mm)	21.1	18.8	3*
Md dentition			
Md 1, to APo (mm)	1	4.6	2*
Md 1, inclination (dg)	22	25	4
Md 1, extrusion (mm)	1.2	0	2*
Hinge axis angle (dg)	90	90	4
Mx/Md dentition			
Interincisor angle (dg)	131	123	4*
Molar relation (mm)	−3	−2.7	1
Incisor overjet (mm)	2.5	3.5	2
Incisor overbite (mm)	2.5	2.8	2
Aesthetic relations			
Lower lip E-plane (mm)	−2	−0.5	2
Steiner analysis			
SNA (dg)	82	82.5	1
SNB (dg)	80	78.3	3*
ANB (dg)	2	3.4	2*
Mx 1 - NA (mm)	4	6.1	3*
Mx 1 - NA angle (dg)	22	24	6
Md 1 - NB (mm)	4	7	3*
Md 1 - NB angle (dg)	25	28	4*
PO - NB (mm)	1	1	1
Occlusal plane - SN (dg)	14	16.1	3*
GO-GN - SN (dg)	32	33.8	4
Interincisor angle (dg)	131	124	4*
Wits appraisal (mm)	1.1	−0.9	1*
Calculated ANB form	2	4.7	1*
Tweed analysis			
FMA (dg)	25	27	4*
FMIA (dg)	65	57	4*
IMPA (dg)	90	96	4*

FMA – Frankfurt to mandible plane angle; FMIA – Frankfort horizontal to mandibular incisor angle; IMPA – Incisor to mandibular plane angle; SD – Standard deviation

Table 2: Comparison of cephalometric norms between Caucasian and a Mexican female group for the Ricketts, Steiner and Tweed analyses, mean age = 17 years, *N* = 50

Cranial relations	Caucasian	Mexican	±SD
Ricketts analysis			
Ant cranial base (mm)	59.4	57.1	2
Post-facial height (mm)	54.8	64.3	3*
Cranial deflect (dg)	27.3	29	3
Porion location (mm)	−38.6	−39	2
Ramus position (dg)	76	74.5	3*
Mx position			
Maxillary depth (dg)	90	90.3	3*
Maxillary height (dg)	55.2	60	3*
SN-palatinal plane (dg)	7.3	8.3	3
Md position			
Facial depth (dg)	88.3	87.9	3*
Facial axis (dg)	90.0	87.2	3
Mandibular plane (dg)	26	27	4
Total facial height (dg)	60	61.8	3
Facial taper (dg)	68	65.9	3*
Maxilla/mandible relations			
Convexity (mm)	0.9	2.8	2*
Corpus length (mm)	73.8	70.4	4*
Mandibular arc (dg)	29.8	32.8	4*
Lower facial height (dg)	47	48.5	4*
Denture relations			
Mx dentition			
Mx 1, to APo (mm)	3.5	8.7	2*
Mx 1, to FH (dg)	111	117	6*
Mx 6, to PTV (mm)	17.1	17.1	3
Md dentition			
Md 1, to APo (mm)	1.0	4.7	2*
Md 1, inclination (dg)	22	26.2	4
Md 1, extrusion (mm)	1.2	−0.2	2*
Hinge axis angle (dg)	90	90	4
Mx/Md dentition			
Interincisor angle (dg)	130	122	4*
Molar relation (mm)	−3	−2.1	1*
Incisor overjet (mm)	2.5	4.1	2*
Incisor overbite (mm)	2.5	1.9	2*
Aesthetic relations			
Lower lip E-plane (mm)	−2	0	2*
Steiner analysis			
SNA (dg)	82	81.6	3
SNB (dg)	80	78.6	3
ANB (dg)	2	3	2*
Mx 1 - NA (mm)	4	7.6	3*
Mx 1 - NA angle (dg)	22	27.4	6*
Md 1 - NB (mm)	4	7.2	3*
Md 1 - NB angle (dg)	25	28.5	6
PO - NB (mm)	1	−0.2	1
Occlusal plane - SN (dg)	14	17.8	3*
GO-GN - SN (dg)	32	34.8	4*
Interincisor angle (dg)	130	121.6	6*
Wits appraisal (mm)	1.1	−2.9	1*
Calculated ANB form	2	4.4	1*
Tweed analysis			
FMA (dg)	25	26	4*
FMIA (dg)	65	59	4*
IMPA (dg)	90	95	4*

FMA: Frankfurt to mandible plane angle, FMIA: Frankfort horizontal to mandibular incisor angle, IMPA: Incisor to mandibular plane angle, SD: Standard deviation

Table 3: Comparison of cephalometric and facial norms between Caucasian and a Mexican group for the Arnett Facial analysis, average age = 19 years, *N* = 50

Dentoskeletal	Caucasian	Mexican	±SD
Arnett analysis			
Mx occlusal plane (dg)	95	95	4
Mx1 to Mx occlusal (dg)	54	57.4	4
Md1 to Md occlusal (dg)	64	64	4
Overjet (mm)	3.5	3.5	1
Overbite (mm)	3	3	1
Soft tissue structures			
Upper lip thickness (mm)	13	13	3
Lower lip thickness (mm)	14	12.5	3*
Pog to Pog' (mm)	12	13.5	2*
Menton to Menton' (mm)	7	8.5	2
Nasolabial angle (dg)	101	105.4	8*
Upper lip angle (dg)	10	13	3*
Facial lengths			
Na' to Me' (mm)	127	133.5	5*
Upper lip length (mm)	22.5	23.5	2
Interlabial gap (mm)	4	4	4
Lower lip length (mm)	48	51.4	4*
Lower 1/3 (mm)	75	75	6
Overbite (mm)	3	3	1
Mx 1 exposure (mm)	4	5	2*
Maxillary height (mm)	26	26	3
Mandibular height (mm)	50	52	3*
Projection to TVL			
Glabella' (mm)	−10	−13.3	3*
Orbital rim (mm)	−20	−22.3	3*
Cheekbone (mm)	−21	−24.4	4*
Subpupil (mm)	−16	−17	3
Alar base (mm)	−12	−14.4	3*
Nasal projection (mm)	15	15	2
Subnasale (mm)	0	0	2
Soft A' point (mm)	−1	0.4	2*
Upper lip anterior (mm)	3	3.9	2
Upper incisor (mm)	−10	−8.5	2*
Lower incisor (mm)	−13	−11.6	2*
Lower lip anterior (mm)	1.5	1.5	2
Soft B' point (mm)	−5	−5	2
Pog' (mm)	−3	−3	2
Facial harmony			
Mandibular balance			
Md 1 to Pog' (mm)	10	10	3
LLA to Pog' (mm)	4.5	4.5	2
B' to Pog' (mm)	2	2	2
Throat length (mm)	58	62.1	6*
Inter jaw balance			
Sn to Pog' (mm)	3	3	2
A' to B' (mm)	4	5.3	2*
ULA to LLA (mm)	2	2	2
Orbit to Jaws			
Orbit to A' (mm)	19	22.3	3*
Orbit to Pog' (mm)	17	19.4	4*
Full facial balance			
Facial angle (dg)	167.5	167.5	5
Gb' to A' (mm)	9	13.3	3*
Gb' to Pog' (mm)	9	9	5

SD — Standard deviation; TVL – True vertical line; ULA – Upper lip anterior; LLA – Lower lip anterior

to Caucasians. The interincisal angle of 123° in males and 122° in females were more acute and statistically different when compared to Caucasians in whom the norm is 131°.

Esthetic relations

The lower lip to the E-plane in the Mexican females is more protrusive than the Caucasian females.

Steiner analysis results

Cranial relations

Mexican females showed a Pog-NB of −0.2 mm which was statistically lesser than in Caucasian females (1 mm). The Occlusal Plane-SN angle presented significant differences in both Mexican males (16.1°) and females (17.8°) when compared to their Caucasian counterparts who showed a more acute angle (14°).

Maxilla/mandible relations

There was a statistically significant difference for the SNB angle between the Mexican males (76.3°) and Caucasian males (80°). The ANB norm for the Mexican male was statistically higher (3.4°) when compared to Caucasian (2°). The Mexican males and females presented a lower measurement for the Wits Appraisal at −0.9 mm and −2.9 mm with a higher ANB difference of 4.7 mm and 4.4 mm respectively.

Dental relations

For both Mexican males and females, the maxillary incisor to NA (6 mm and 7 mm respectively) and mandibular incisor to NB (7 mm for both) values were statistically higher showing that their incisors were more protrusive and proclined than in the Caucasians. The interincisal angle was statistically different in both Mexican males (124°) and females (122°) when compared to Caucasians (131°).

Tweed analysis results

The Frankfurt to mandible plane angle of (25°) for Caucasians is statistically different than that for Mexican males (27°) and females (26°).

The incisor to mandibular plane angle was statistically different for both Mexican males (96°) and females (95°) showing more proclined and protrusive lower incisors when compared to Caucasians (90°). The Frankfort horizontal to mandibular incisor angle for both Mexican males (57°) and females (59°) was statistically more acute.

AFA results

Cranial relations

Glabella to TVL in the Mexican group showed a larger distance in comparison with Caucasians. The orbital rim, cheekbone, alar base and subpupil measurements, were statistically less protrusive which means that the Mexican group had a flatter medial third of the face.

Inter jaw balance (maxilla/mandible relations)

Soft-tissue A-point to soft-tissue B-point was statistically longer in the Mexican sample than the Caucasian.

Dento-skeletal relations

The upper incisor and lower incisor in relation to TVL showed statistically higher values than those in Caucasians meaning that the Mexican population presented a more protrusive upper and lower incisor position and also a more protruded soft-tissue A-point.

Soft-tissue structures

The upper lip thickness did not present any significant difference between both groups; but the lower lip thickness showed a statistically significant difference between the Mexican (12.5 mm) and Caucasian (14 mm) group. The naso-labial angle was more obtuse in the Mexican group (105.4°) when compared to the Caucasian (101°).

Orbit to jaws

Orbit to soft-tissue A-point and Orbit to soft tissue pogonion projection presented a longer measurement for the Mexican group indicating that they have a longer anterior face height.

Full facial balance

Glabella to soft-tissue A-point is longer in the Mexican group; meaning that the middle third of the face is longer than in the Caucasian group.

DISCUSSION

Most existing cephalometric analyses are based on norms for Caucasian ethnic groups. Therefore, they cannot be properly applied for Mexican or Hispanic patients. Ethnic variations in the normal positions of the maxilla and mandible modify and alter the diagnosis and treatment plan for each of the different types of malocclusions. Previous studies had examined cephalometric and anthropometric differences between the Caucasian and the Hispanic populations but unfortunately by addressing children and non-pure ethnic groups and therefore, the results could be controversial.

Canavati,[2] Kennedy,[3] Velarde,[4] Garcia[5] and Bishara and Fernandez[6] evaluated cephalometric comparisons between two different ethnic groups in an active growth stage. Although using growing samples in both cases and with most of them living in the United States, the variables of growth and pure ethnicity were not taken under consideration and this could result in less valid and weak information.

The main flaws of the previous studies is that none of them used the homogeneity and purity of a Native-Mexican ethnic population and most of this research used growing patient groups; therefore, growth is one of the most important variables that had to be addressed considering the fact that secondary ethnic features are 100% developed and expressed after growth completion.

Swlerenga *et al.*,[7] analyzed 48 Mexican-American adult patients with parents or grandparents born in Mexico. Again although having a Mexican background the ethnic purity of the sample group was weak. Although other several studies and publications describe greater degrees of lip and incisor prominence in Asians and African-Americans, just a few studies have been published based on a pure Mexican population describing their skeletal and soft tissue differences. Until date, there has not been a study that described the specific cephalometric and anthropometric characteristics for a pure, non-growing Mexican population. Therefore, it is both logical and important to use craniofacial measurements that include cephalometric norms for Latin-American and Hispanic populations, which are as shown in the study, different from the standard cephalometric Caucasian norms.

CONCLUSIONS

The importance of facial esthetics in orthodontics has induced practitioners to be more precise in the clinical and record examinations. The very well defined difference between ethnic groups has also motivated the orthodontist to create specific norms for each ethnic group so that the best functional, esthetic and long-term stable results can be obtained.

Cephalometric and facial norms for a sample of Mexican patients were established in this study to create specific guidelines for this ethnic group so that the most pleasing dental and facial esthetics of a patient belonging to this ethnic population could be achieved.

A specific ethnic population was studied for cephalometric and soft-tissue measurements. The established norms were compared with the Caucasian norms and the main differences were reported. The development of these new cephalometric and aesthetic norms will aid the orthodontist in creating the best diagnosis and treatment plan for the significant and increasing Latin-American (Hispanic) population searching for orthodontic treatment worldwide.

This will be especially useful for the orthodontist and maxillofacial surgeon when performing a VTO or STO for an orthognathic surgery procedure to resolve skeletal and dental abnormalities.

The newly established norms can also be applied in diagnosis and treatment planning of Native Americans in the USA and Hispanics from Central and South American countries due to the strong similarities in the anthropometric and ethnic backgrounds with the Mexican population.

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