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Original Research Article

Association Between Transverse Collapse of the Maxilla and Facial Biotypes by Cone Beam Tomography

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Abstract: ***Introduction:*** Skeletal unit growth may be due to epigenetic influence exerted by the functional matrix on the skeleton. Penn analysis is a method used to evaluate tomographically the transverse alterations of the maxilla. ***Objective:*** To analyze the association between transverse collapse of the maxilla and facial biotype in patients of the Polyclinic of the Orthodontics Postgraduate Program of the Autonomous University of Baja California, Mexicali campus. ***Materials and methods:*** An observational, analytical and cross-sectional study was carried out. The sample consisted of 75 patients who met the inclusion criteria. Initial tomographic studies were used to determine the presence of transverse collapse by means of Penn analysis. Lateral skull teleradiographs were plotted to determine the facial biotype by means of the Vert coefficient of Ricketts' lateral cephalometric analysis. The *chi-square* test was performed for statistical analysis of the association between the presence of transverse collapse of the maxilla and facial biotypes. ***Results:*** No significant results were found between the *chi-square* values and the *p-value* for patients with transverse collapse of the maxilla in association with facial biotypes. However, a statistical *chi-square* value of 4.8422 and a *p-value* of 0.2777 were obtained for the sample of female patients with transverse collapse of the maxilla. ***Conclusions:*** No association was found between the presence of maxillary transverse deficiencies and facial biotypes.

Keywords: Maxillary collapse, Facial biotype, Computed tomography, Cone Beam tomography.

INTRODUCTION

During craniofacial growth and development there are skeletal changes that affect the maxilla in the three directions of space: vertical, horizontal and transverse. Among these changes, deficiencies in transverse development are the most frequent, and can occur alone or in relation to other alterations [1].

To effectively correct any dentofacial deformity involving a transverse deficiency, early and accurate diagnosis and treatment is imperative for stability [2].

Diagnosis of maxillary transverse deficiencies can be difficult, and often involves the use of more than one of the following methods: clinical evaluation, dental model analysis, articulator mounting and craniofacial radiographs [10].

One of the diagnostic records for the assessment of the bony bases at the transverse level is the Penn analysis, which was performed at the University of Pennsylvania in 2010 (by Simontacchi Gbologah, Tamburrino, Boucher, Vanarsdall and Secchi). For maxillary width, the same jugal point as Ricketts is used, since it is assumed that the maxilla begins at the projection of the center of resistance of the upper teeth on the buccal surface of the bony cortex. For the mandibular width, on the other hand, the representation of the Wala Ridge described by Andrews in his study

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based on plaster models of the patient is used. This is close to the cortical edge of the bone opposite the furcation of the lower first molars [19].

On many occasions, alterations at the transverse level of the maxilla are not adequately diagnosed because the orthodontic diagnosis is made on cephalometry obtained from a lateral teleradiography of the skull, and clinical inspection is not enough to consider the presence of a correct relationship between the upper and lower bony bases due to the possible compensations at the dental level that may develop during dental eruption.

The lack of information obtained from a two-dimensional (2D) radiographic image has led us to introduce cone beam computed tomography as a primary diagnostic tool in clinical practice. The ideal diagnosis in the three planes of space to identify the presence of an alteration in the transverse dimension of the maxilla is of utmost importance for the correct diagnosis and the planning of an efficient treatment plan.

The objective of this study is to associate maxillary collapse with facial biotypes in patients attending the orthodontic clinic of the Polyclinic at the Autonomous University of Mexicali, Baja California, by means of Penn analysis in cone beam tomography and determination of the Vert of Ricketts analysis.

Materials and Methods

An observational, analytical, cross-sectional study was carried out from February 2021 to July 2023, in the Orthodontics postgraduate program at the School of Dentistry of the Autonomous University of Baja California.

The sample consisted of 75 patients from the polyclinic of the orthodontic postgraduate program of the Universidad Autónoma de Baja California Mexicali, who met the established inclusion criteria.

The sample inclusion criteria were:

- Patients admitted for treatment for the first time to the orthodontic department of the UABC School of Dentistry.
- Patients with permanent dentition.
- Patients over 14 years of age.
- Prior authorization to be part of the study.

On the other hand, the exclusion criteria for the sample were:

- Patients with craniofacial anomalies and/or syndrome.
- Patients with missing teeth.
- Patients with functional habitus.
- Patients with a history of craniofacial trauma.

In order to carry out the research, initial diagnostic studies were used for each of the patients in the sample, which were lateral skull radiographs and full cone beam computed tomography of the head. The studies are part of the clinical history and database of the orthodontic postgraduate program of the School of Dentistry Mexicali of the Autonomous University of Baja California, so in order to compile the necessary information we took into account those files that had informed consent.

A spreadsheet was created in Microsoft Excel 365 to compile the relevant information for the study with respect to the patients in the sample, including the following data: name, sex, Vert index, maxillary transversal measurement and mandibular transversal measurement.

To obtain the facial biotype, lateral skull teleradiographies were taken with a Carestream tomograph, model: CS9300C, year: 2015. The emitting focus is positioned at a minimum distance of 1.5 meters which can range up to 4 meters from the radiographic plate, located on the other side of the head.

The patient's head was oriented in space in order to obtain parallelism of the Frankfurt plane with the ground and the mid-sagittal plane to the radiographic plate. This was done in order to standardize the diagnostic imaging.

The cephalometric analysis of each one of the lateral teleradiographies of the skull of the patients in the sample was elaborated, then the Vert coefficient and facial biotype were determined in a conventional way on a matte acetate paper with a *Techniclick Pentel* PD105T 0.5 mm fine pen. All cephalometric procedures were performed by a single examiner in random order.

A Carestream 3D Imaging tomographic viewer was used to perform the Penn analysis. Subsequently, the transverse measurements of the maxilla and mandible were determined as follows: the upper right and left jugal skeletal points were located within the axial and sagittal section (Fig:1 and 2). The distance between these two points is recorded linearly. The maxillary transverse measurement was recorded and entered into the database in the Excel Microsoft 365 program.

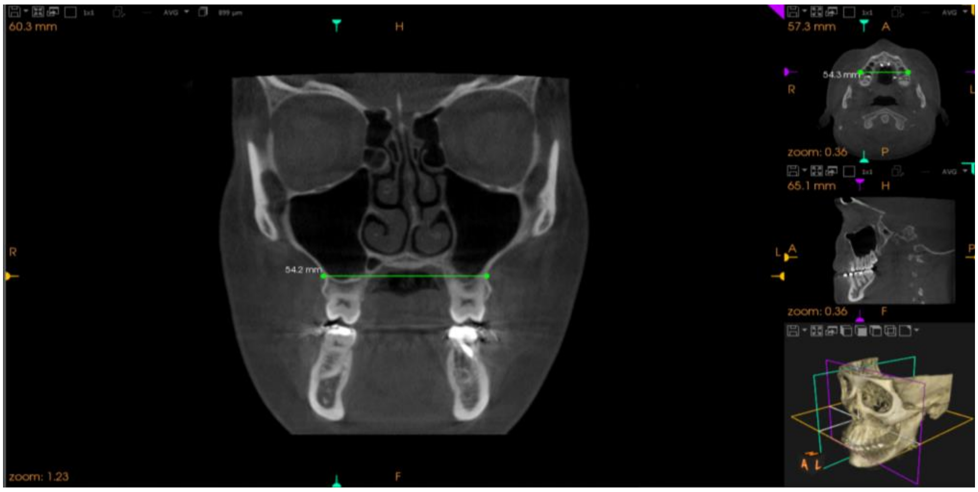

Fig. 1: Sagittal view of the maxilla. Author's source: tomography of patient of the orthodontic postgraduate course of the Universidad Autónoma de Baja California Mexicali

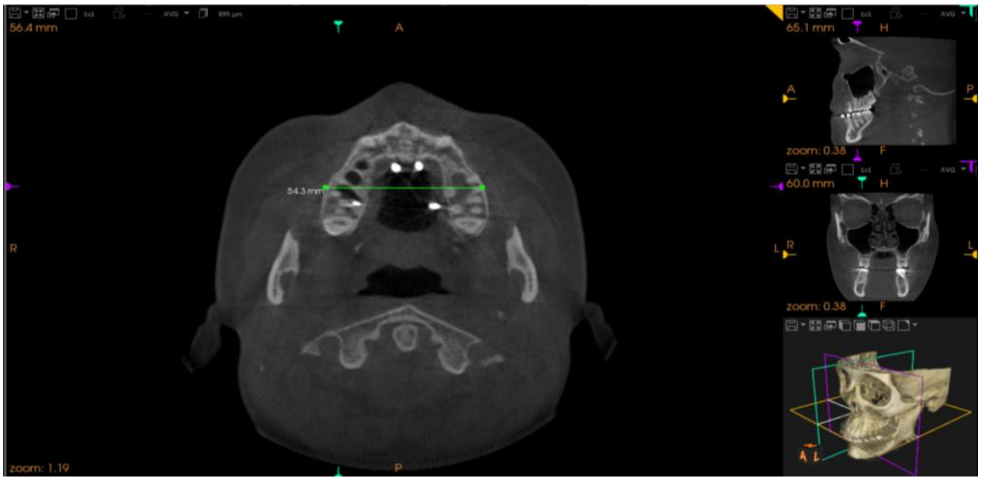

Fig. 2: Maxillary measurement axial section. Author's source: tomography of patient of the orthodontic postgraduate course of the Universidad Autónoma de Baja California Mexicali

For the mandibular measurement, the skeletal points of the right and left WALA point representation are located within the axial and sagittal section (Fig: 3 and 4).

Fig. 3: Mandibular measurement sagittal section. Author's source: tomography of patient of the orthodontic postgraduate course of the Universidad Autónoma de Baja California Mexicali

Fig. 4: Mandibular measurement in axial section. Author's source: tomography of patient of the orthodontic postgraduate course of the Universidad Autónoma de Baja California Mexicali

The mandibular measurement is also recorded in the database. The discrepancy between the upper and lower bone bases is determined using the following formula:

edida Maxilar (Mx-Mx)-Medida mandibular (WALA-WALA)= 5 ≥ mm.

Once the results of the Penn analysis were obtained, the decision was made to classify into groups according to the severity of collapse; the group with transverse collapse of the maxilla was considered: mild when there were differences in a range of 4.9 mm to 4 mm; moderate when there were differences of 3.9 mm to 2.5 mm and severe with differences of 2.4 mm or less.

Results and Discussion

The total number of patients in the sample consisted of 37 female patients (49%) and 38 male patients (51%) (Fig:5). The average age of the patients in the sample was 27 years and the arithmetic median was 22 years.

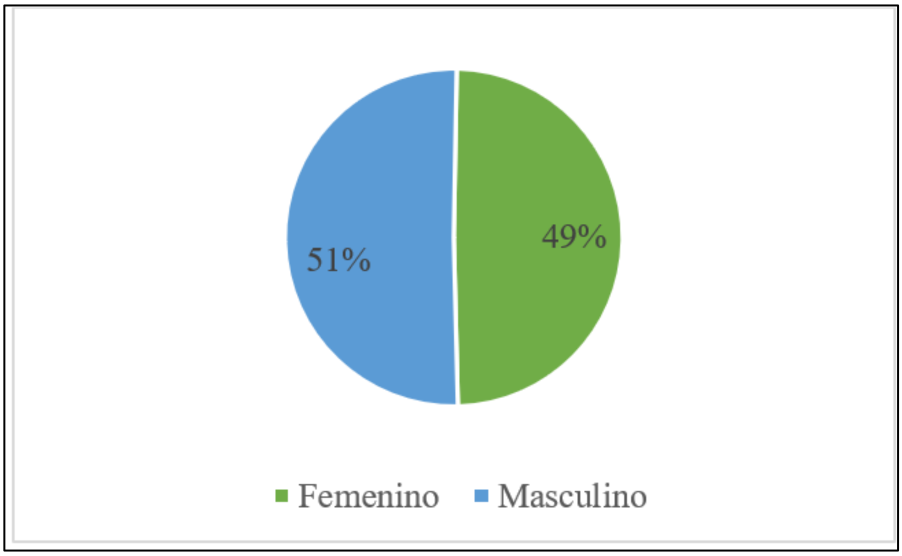

Fig 5: Percentage of patients in the sample by sex

Based on the Ricketts cephalometric analysis and the measurements to determine the Vert of the patients in the sample resulted in 36 brachyfacial patients (48%), 24 dolichofacial (32%) and 15 mesofacial (20%) (Fig: 6).

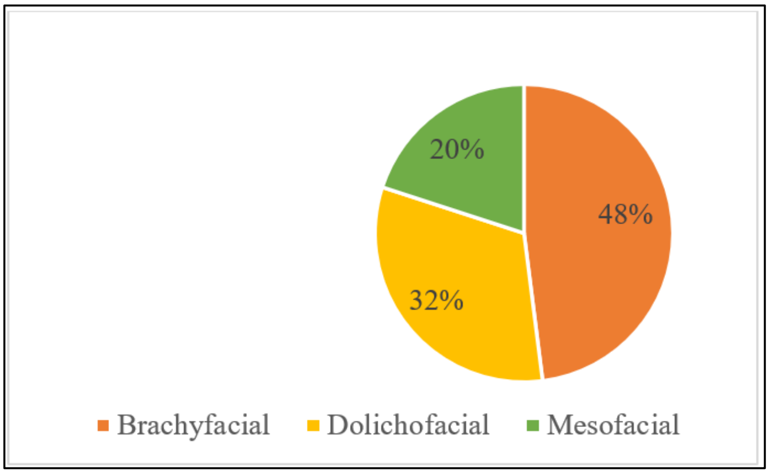

Figure 6: Percentage of patients shown by facial biotype

The measurements of the differences between the maxillary and mandibular measurements from the Penn analysis yielded the following data, 39 patients outside the norm with presence of maxillary transverse collapse (52%) and 36 patients in norm without maxillary transverse collapse (48%) (Fig: 7).

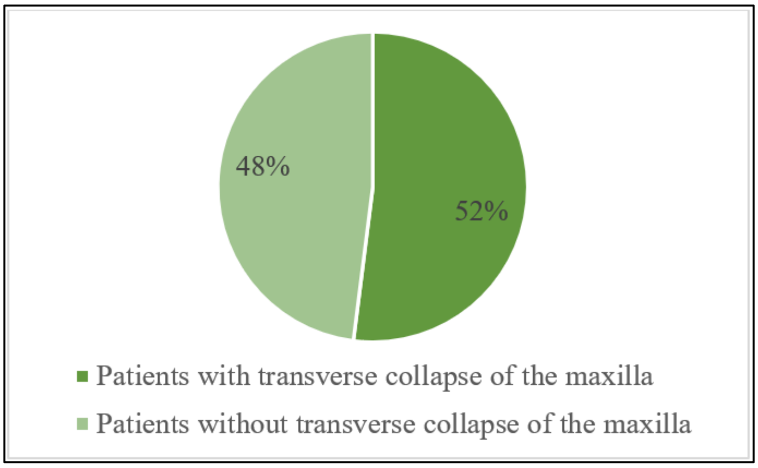

Figure 7: Percentage of patients with presence of maxillary transverse collapse

Of the 39 patients with presence of transverse collapse of the maxilla, 18 (46%) had a brachyfacial result according to Ricketts' Vert, 14 (36%) dólicofacial and 7 (18%) Mesofacial (Fig: 8). Of the 36 patients in norm according to Penn's analysis, 18 (50%) had a brachyfacial result according to Ricketts' Vert, 10 (28%) dólicofacial and 8 (22%) mesofacial.

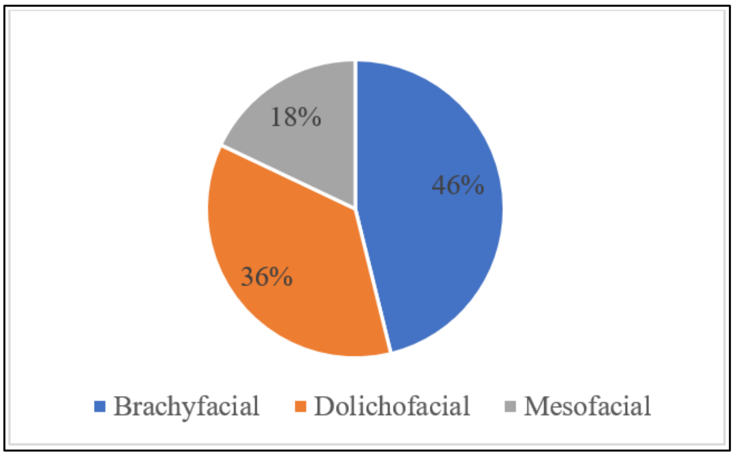

Figure 8: Percentage of patients with transverse collapse of the maxilla by facial biotype

In the sample groups with respect to sex, they resulted in 24 (65%) female patients with transverse collapse of the maxilla of which, 10 patients were classified as brachyfacial, 11 dolichofacial and 3 mesofacial (Fig: 9); and 13 (35%) without transverse collapse of the maxilla, 5 patients were brachyfacial, 3 dolichofacial and 5 mesofacial; 15 (39%) male patients with transverse collapse of the maxilla, 8 patients were brachyfacial, 3 dolichofacial and 4 mesofacial (Figure 10); and 23 (61%) without transverse collapse of the maxilla, 13 patients were brachyfacial, 7 dolichofacial and 3 mesofacial.

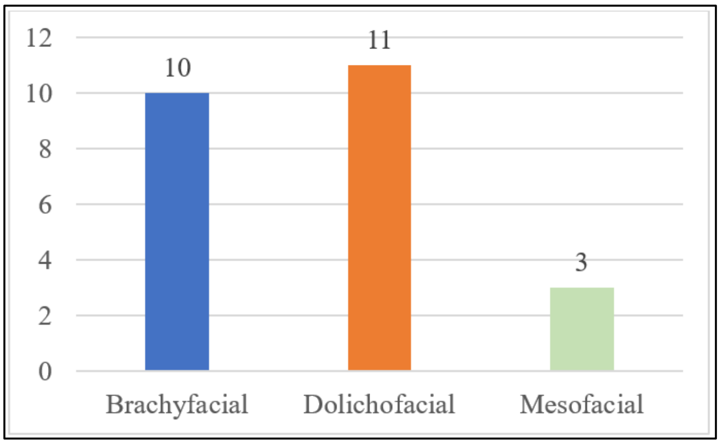

Figure 9: Total number of female patients with transverse collapse of the maxilla by facial biotype

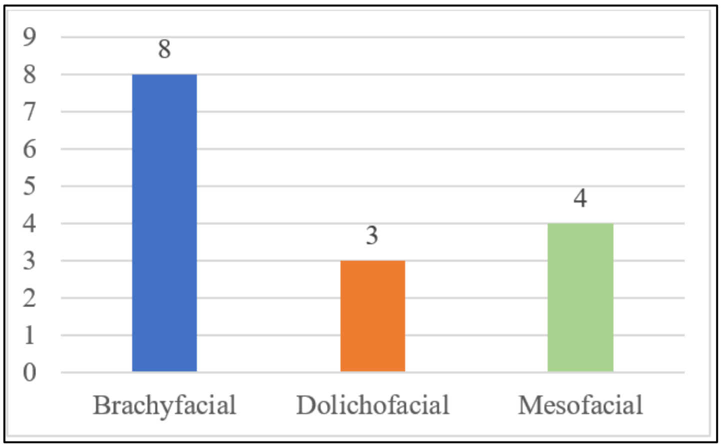

Figure 10: Total number of male patients with transverse collapse of the maxilla by facial biotype

In the group classification we obtained 3 (8%) patients with mild collapse, 7 (18%) moderate and 29 (74%) severe collapse (Fig: 11). In the mild and moderate groups all patients belonged to a brachyfacial Vert, while in the severe collapse group, 8 (28%) patients belonged to a brachyfacial biotype, 14 (48%) to a dolichofacial biotype and 7 (24%) to a mesofacial biotype (Fig: 12).

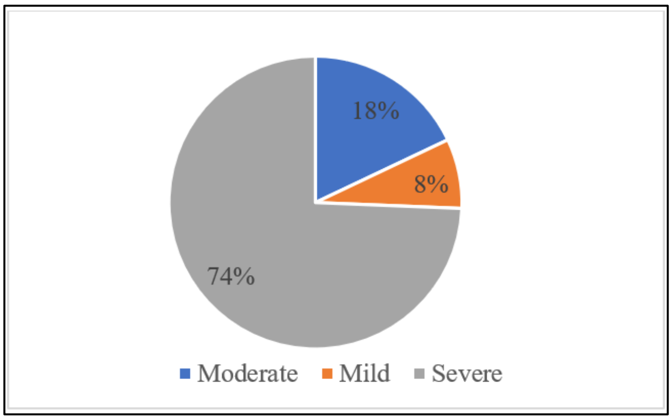

Figure 11. Percentage of patients with transverse collapse according to severity

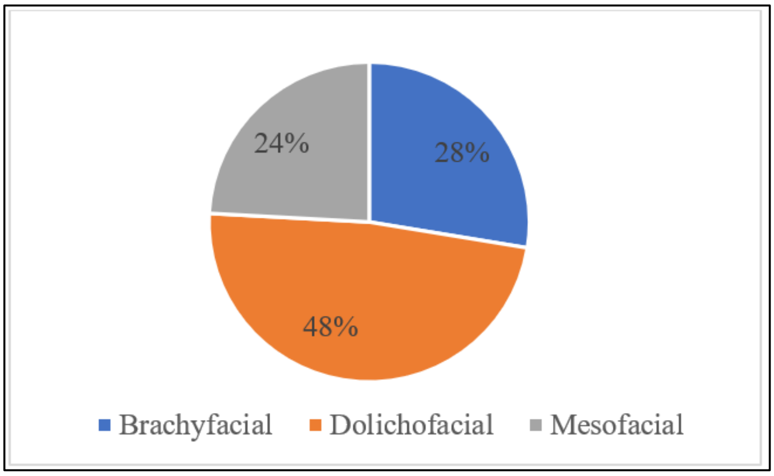

Figure 12. Percentage of patients with severe transverse collapse of the maxilla by facial biotype

Of the male sample, 1 (6%) patient had mild collapse, 4 (27%) patients had moderate collapse and 10 (67%) patients had severe collapse (Fig: 13).

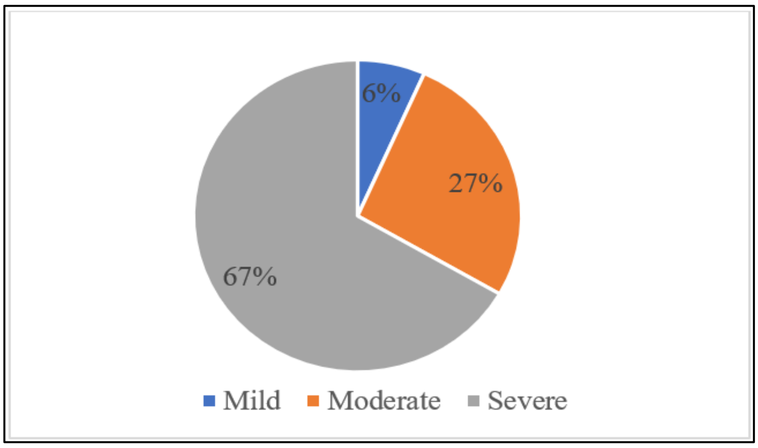

Figure 13. Percentage of male patients with transverse collapse of the maxilla by severity

On the other hand, in the female sex, 2 (8%) patients presented mild collapse, 3 (13%) moderate and 19 (79%) severe collapse (Fig: 14).

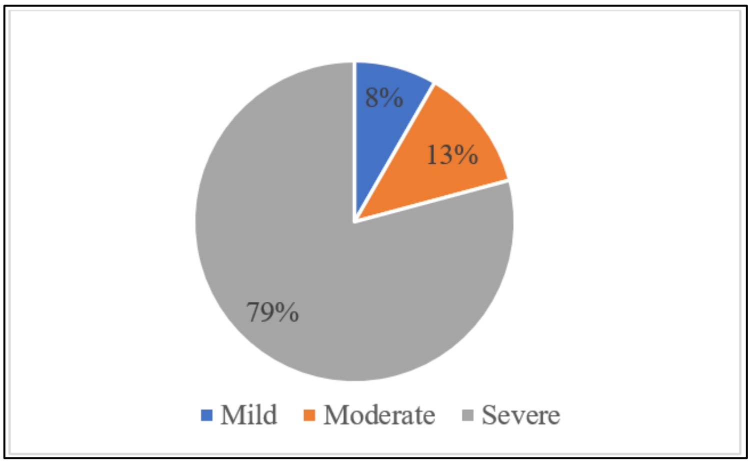

Figure 14. Total number of female patients with maxillary transverse collapse by severity

Once all the sample data had been obtained, we proceeded to obtain the statistical data for the study. For this purpose, a *chi-square* test was performed for each of the facial biotype and sex variables (Tables: 1 to 7).

Table 1: *Chi-square* test between brachyfacial and mesofacial patient samples.

Facial biotype	With collapse	No collapse	Marginal totals
Brachyfacials	18 (17.65) [0.01]	18 (18.35) [0.01]	36
Mesofacial	7 (7.35) [0.02]	8 (7.65) [0.02]	15
Marginal totals	25	26	51 (Total)

The *chi-square* statistic is 0.0471. The *p-value* is .82823. There is no significance *p-value* <.05.

Table 2: *Chi-square* test between brachyfacial and dolichofacial patients

Facial biotype	With collapse	No collapse	Marginal totals
Brachyfacials	18 (19.2) [0.07]	18 (16.8) [0.09]	36
Dolichofacials	14 (12.8) [0.11]	10 (11.2) [0.13]	24
Marginal totals	32	28	60 (Total)

The *chi-square* statistic value is 0.0418. The *p-value* is .526168. There is no significance *p-value* <.05.

Table 3. *Chi-square* test between mesofacial and dolicofacial patient samples

Facial biotype	With collapse	No collapse	Marginal totals
Mesofacial	7 (8.08) [0.14]	8 (6.92) [0.17]	15
Dolichofacials	14 (12.92) [0.09]	10 (11.08) [0.1]	24
Marginal totals	21	18	39 (Total)

The *chi-square* statistic is 0.5056. The *p-value* is .477069. There is no significance *p-value* <.05.

Table 4: *Chi-square* test between mesofacial and non-mesofacial patients

Facial biotype	With collapse	No collapse	Marginal totals
Mesofacial	7 (7.8) [0.08]	8 (7.2) [0.09]	15
Non-mesofacial	32 (31.2) [0.02]	28 (28.8) [0.02]	60
Marginal totals	39	36	75 (Total)

The *chi-square* statistic is 0.2137. The *p-value* is .643902. There is no significance *p-value* <.05.

Table 5: *Chi-square* test between brachyfacial and non-brachyfacial patients

Facial biotype	With collapse	No collapse	Marginal totals
Brachyfacials	18 (18.72) [0.03]	18 (17.28) [0.03]	36
Non-brachyfacial	21 (20.28) [0.03]	18 (18.72) [0.03]	39
Marginal totals	39	36	75 (Total)

The *chi-square* statistic is 0.1109. The *p-value* is .739069. There is no significance *p-value* <.05.

Table 6: *Chi-square* test between dolichofacial and non-dolichofacial patients

Facial biotype	With collapse	No collapse	Marginal totals
Dolichofacials	14 (12.48) [0.19]	10 (11.52) [0.2]	24
Non-dolichofacials	25 (26.52) [0.09]	26 (24.48) [0.09]	51
Marginal totals	39	36	75 (Total)

The *chi-square* statistical value is 0.5672. The *p-value* is .613292. There is no significance *p-value* <.05.

Table 7: *Chi-square* test between female and male patient samples

Sex	With collapse	No collapse	Marginal totals
Female	24 (19.24) [1.18]	13 (17.76) [1.28]	37
Male	15 (19.76) [1.15]	23 (18.24) [1.24]	38
Marginal totals	39	36	75 (Total)

The *chi-square* statistic is 4.8422. The *p-value* is .0.27771. There is no significance *p-value* <.05.

To obtain the results of this study, the Ricketts cephalometric tracing was performed on the lateral skulls of each patient to obtain the facial biotype by means of the Vert. The 3D image study was used to determine the width of the upper jaw and its relationship with the lower bone base by means of Penn analysis. All images were standardized to avoid any type of bias.

Thanks to technological advances, today cone beam computed tomography is a tool that allows us to evaluate in a complete way the anatomical structures of bone and soft tissues of the head and neck. There are few studies about cephalometric analysis performed in 3D images.

Due to the fact that diagnosis and treatment planning in three-dimensional images continue to be the subject of research and of little use in the daily routine of clinical practice in orthodontic treatment, there are not enough studies related to the subject and there is a lack of information on the subject. When comparing other previous research, studies were found that sought to associate the deficiencies in the transversal development of the maxillary arch with the different facial biotypes. However, the methods used in previous studies to determine maxillary width measurements were different.

In the case report, carried out by Ubilla Mazzini et al. in 2016, they establish maxillary discrepancy as the origin of dental or skeletal alterations that manifest themselves in crowding, alterations of the facial profile, lip incompetence, among others, which is not far from the little literary reality, since a maxillary transverse discrepancy that is related to the inclinations of the permanent molars can cause alterations in the occlusion [20].

No association was found between shape, maxillary transverse collapse and facial biotypes. However, an association was found between female sex and the presence of maxillary transverse collapse where the *chi-square* statistic is 4.8422 and the *p-value* is .0.27771.

In 2022 Bustos and Ramos carried out a tomographic study in which they correlated the maxillary transverse distance and the inclination of upper permanent molars in skeletal class I adults. In this study 120 tomographies were evaluated in adult patients older than 18 years in a province of Ecuador. In this research it was determined that the average maxillary transverse distance was 55.03 mm, a maximum of 65.43 mm and a minimum of 46.75 mm. It was established that in the female sex the mean values were 33.7 mm, 38.3 mm and 44.4 mm and in the male sex the values were higher [21].

In the study by Garza Madero et al. carried out in 2023, initial study models were used using the Ponts index and initial skull laterals, in order to associate dentofacial components such as arch form, face shape and facial biotype in patients presenting maxillary compression. In this research a high correlation was observed for triangular arch form, dolicofacial biotype and concave biotype in the male gender [22].

The facial biotype, as its name refers, describes phenotypic diversifications that are revealed in people either from the same population or among others. Determining the facial biotype has always been of great importance for the clinician, since this parameter can adequately plan the treatment and thus its favorable prognosis when applying the biomechanics according to the growth pattern [23].

Despite the existence of similar previous studies in which the phenomenon of maxillary compression was studied. To this day there is no other similar study where the transverse distance of the maxilla has been measured by means of Penn tomographic analysis to associate it with facial biotypes. Previous research has been done on the determination of the transverse distance of the upper jaw based on measurements made on plaster models. During the process of elaboration of the study model there may be steps in which the final proportion of the model may be modified with respect to the real proportion of the patient. In the model analyses performed in such previous research, the measurements from one point to another are based on points located on soft tissues, which could in turn also give inaccurate results on a bony structure.

With respect to the above, it would not be so convenient to discuss and compare the different studies carried out previously because each one is made with different approaches and methodologies; there are significant coincidences that allow having relatively similar conclusions, although it is necessary to standardize the diagnostic methods through further research, in order to provide useful information for the diagnosis of alterations of the craniofacial complex.

CONCLUSIONS

With the advancement of technology, cone beam computed tomography (CBCT) has become the diagnostic tool of choice with the highest known certainty that allows us to evaluate the hard anatomical structures of the head and neck. There are not enough studies of cephalometric analysis in cone beam computed tomography (CBCT). Penn's tomographic analysis is very useful for the diagnosis of deficiencies in the transverse development of the maxilla, so it should be used in conjunction with the clinical evaluation and other diagnostic images at the time of treatment planning.

In the present study no association was found between the presence of a deficiency in the transverse development of the maxilla and any facial biotype. On the other hand, a slight association was found between female sex and the presence of maxillary transverse collapse, so we can deduce that female patients have a tendency to present most of the times deficiencies in the transverse development of the maxilla and that this will be a factor to consider at the moment of the clinical and cephalometric evaluation. A high frequency of severe maxillary collapse was observed among patients of the dolicofacial biotype.

Based on the results observed in this study, the following conclusions were reached:

- The hypothesis is rejected, since there is no association between the presence of transverse maxillary deficiencies and facial biotypes.
- The dolichofacial facial biotype presents the highest frequency in the cases registered with transverse collapse of the maxilla.
- The sample of female patients presented positive association values for the presence of transverse

collapse of the upper jaw with a *chi-square* statistic value of 4.8422 and a *p-value* of .0.27771.

- The highest frequency of severe transverse collapse was observed in the female sample.

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