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Lateral Cephalometric Assessment of Bimaxillary Dentoalveolar Protrusion among Filipino Adult Patients with Emphasis on Growth Pattern

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Abstract: This research is conducted to evaluate the bimaxillary protrusion in adult Filipino subjects according the inclusive criteria of this study to investigate the behavior of the discrepancy. Seventy cephalograms were selected according the inclusive and the exclusive criteria for bimaxillary protrusion. Then all were traced and analyzed by the cephalometric analysis with related variables which used in the study. Results of the study showed that the patients with bimaxillary protrusion indicated the high angle mandibular plane partly due to excessive upper posterior dentoalveolar height and partly because of short ramus. The patients showed hyperdivergent facial pattern with decreased overbite which demonstrated skeletal openbite and long face pattern. Filipino patients with bimaxillary protrusion have varied degrees of skeletal vertical discrepancy which makes the primary horizontal discrepancy more complicated. Hence, vertical consideration before any corrective treatment should take into the account regarding the limitations of the orthodontic treatment, especially in the severe cases.

Key words: Bimaxillary dentoalveolar protrusion, cephalometric radiograph, vertical dimension, Filipino, hyperdivergent facial pattern, corrective treatment

INTRODUCTION

Bimaxillary dentoalveolar protrusion: Bimaxillary dentoalveolar protrusion is one of those orthodontic and maxillofacial problems which bring unpleasant facial aesthetics and functional problems. Patients with this condition, mostly often suffer from appearance than functional difficulties. It is a class I malocclusion with protruded incisors, decreased overjet and overbite, procumbent lips and convex profile. It may be defined as one of the most common forms of Asian face, especially in South-East and Arabic countries and African-American profiles (Hussein and Mois, 2007; Shehata, 1982; Aldrees and Shamlan, 2010). Most of the Filipinos show some degrees of bidental protrusion and proclination of incisors (Moldez *et al*., 2006; Naranjilla and Rudzki-Janson, 2005). When it becomes that severe in which an orthodontic treatment is needed, corrective approach to decrease bilabial gap and proclination of the incisors that usually requires the extraction of four first premolars to improve aesthetics and probable breathing problem should be performed (Leonardi *et al*., 2010; Lew, 1989; Tan, 1996).

Etiology is multifactorial and genetic influences as well as environmental components are both involved; habits such as mouth breathing and also tongue size should be taken into account as environmental factors (Adesina *et al*., 2013; Bills *et al*., 2005). Sexual dimorphism in adults with bimaxillary dentoalveolar protrusion in most of angular and linear measurements does exist, however, there is no significant contrast in the general pattern (Moldez *et al*., 2006).

Craniofacial complex: Craniofacial basic fundamentals turn to parts and counterparts which may have enhancing or reducing growth influences with regulating signals of mitotic and differential activities coming from blast cells of the soft tissue matrix, in addition, it has been recognized that the anterior cranial base, nasomaxillary complex and upper and lower dental arches are parts and counterparts while the posterior cranial base, oropharynx and ramus have the same relationships as well (Enlow, 1990). In brief, it could be said that, first, the growth of maxillary complex, depends on the expansion of its structure, following the soft tissue growth by way of primary displacement and second, via. expanding the posterior cranial components through secondary displacement. In the mandible, the growth pattern is quite different and ramus action is critical. Condyle and ramus are counterparts of posterior cranial base and have a role to make the lower dental base position possible to place in a proper relation against the maxillary arch; ramus grows vertically and horizontally with regards to induced frame of posterior cranial base (Enlow, 1990; Moyers 1988).

Previous studies always focused on the bimaxillary protrusion as a severe problem in anteroposterior plane of the space and few articles noticed other aspects of the

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malocclusion such as vertical and transverse discrepancies, craniofacial morphology, growth, development and interactions of skeletal structures and there is no comprehensive study about the traits of bimaxillary protrusion in Filipino subjects, furthermore it might be some special characteristics in Filipino individuals which should be seeking to find out for better diagnosis and treatment planning of orthodontic treatment.

The aim of this study is to analyze the cephalometric angular and linear measurements, as well as proportions regarding structural parts and counterparts to completely understand of craniofacial features of the discrepancy in horizontal and vertical planes in Filipino patients for better facing and treating the condition according to precise and practical diagnosing.

MATERIALS AND METHODS

Samples: Selected cephalograms of 70 (22 males and 48 females) individuals with the mean age of 20 who were attended to university orthodontic clinic were elected. Diagnostic records of each patient including intra-oral and extra-oral photographs, panoramic and cephalometric radiographs and dental casts were obtained. Clinical examination and interviews were performed to confirm that the established criteria were observed precisely. Inclusive selection criteria for this study were:

- Bimaxillary protrusion cases with protruded upper and lower incisors and prominent lips that were diagnosed through clinical examination and the analysis of diagnostic records
- Existence of inter-labial gap or extremely hypermentalis activity upon rest position
- Born in Philippines
- Have Filipino grandparents
- Presence of all teeth (except third molars)
- Acceptable oral hygiene

Exclusive selection criteria were as follows:

- With the history of craniofacial trauma or injury
- With the history of orthodontic treatment or maxillofacial surgery
- Existence of oral habits
- With the presence of rampant caries
- With any racial hybridism such as Chinese-Filipino, Spanish-Filipino or Japanese-Filipino

Cephalometry: In order to coordinate and calibrate lateral cephalometric radiographsonly those which were acceptedthat were taken by one X-ray machine

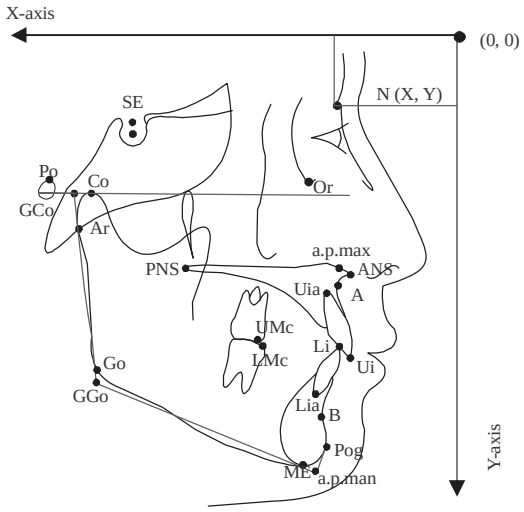

Fig. 1: The landmarks used in this study. Sella (S), the midpoint of Sella tursica Entrance (SE), Nasion (N), Pogonion (Pog), Orbitale (Or), Articular (Ar), Aanterior Nasal Spine (ANS), Posterior Nasal Spine (PNS), point A, point B, Porion (Po), Menton (Me), Gonion (Go), the point at the intersection of ramus line and the mandibular plane (Geometric Go or GGo), the most superior point on the mandibular condyle (Condyle point or Co), the point at the intersection of ramus line and condyle line (Geometric Co or GCo), the projection of A point on the palatal plane (a.p.max), the projection of pog on the mandibular plane (a.p.man), Upper inciso tip (Ui), Lower incisor tip (Li), Upper incisor apex (Uia), Lower incisor apex (Lia), Upper first Molar cusp (UMc), Lower first Molar cusp (LMc)

(Paranourm 15 machine) at the distance of 130 and 15 cm from source to midsagittal plane of the object and film cassette, respectively. Furthermore, the radiographs with highly superimposed structures or having any problems in fixation and development procedures were eliminated from the study.

Cephalometric landmarks, reference lines, linear and angular measurements are shown in Fig. 1-4; for simplicity and better interpretation we divided the cephalometric parameters into skeletal sagittal, dental sagittal, skeletal vectorial, skeletal vertical and dental vertical increments. Three ratios used in this study were:

Jarabak index: Proportion between Posterior Facial Height (PFH) and Anterior Facial Height (AFH) in percentage. Normal range is 61-65%.

Anterior face height index: Proportion between Upper Anterior Face Height (UAFH) and total anterior facial height in percentage which normally is 45%.

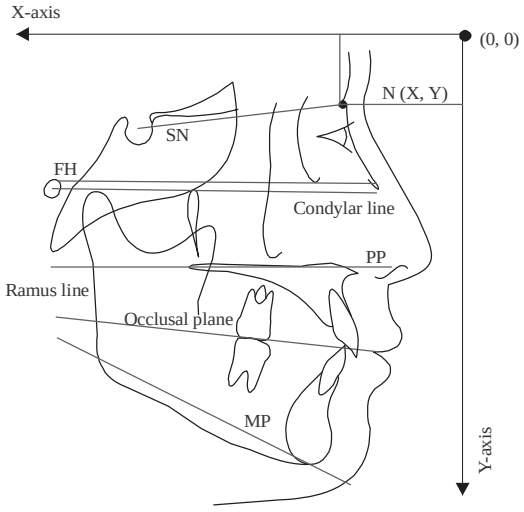

Fig. 2: The reference lines used in this study. Sella Nasion (SN), Frankfort Horizontal (FH), a line extending from geometric Co parallel to FH (Condylar line), a line tamgant to posterior border of ramus (ramus line), Palatal Plane (PP), occlusal plane, Mandibular Plane (MP)

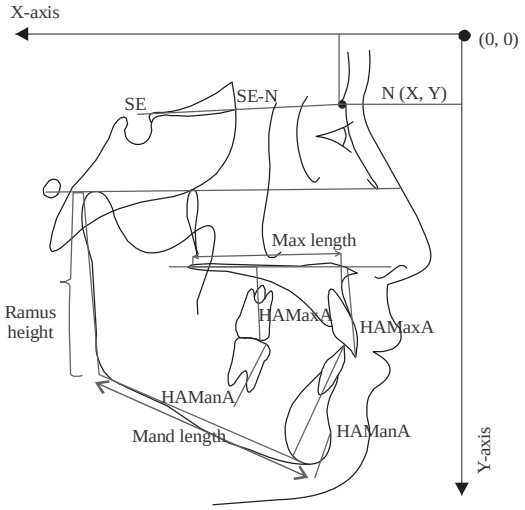

Fig. 3: The linear measurements used in this study. SE-N: represents the length of the anterior cranial base by measuring the distance between SE and nasion point. Maxillary length: the distance between a.p.max and PNS (normally, it must be in the ratio of 2:3 to the lower jaw base 8). Mandibular length: the distance between a.p.man and geometric gonion (normally it must be 3 mm greater than SE-N 8). Ramus height: vertical distance between geometric Co and geometric Go. Upper Anterior Dentoalveolar Height (UADH): the vertical distance between Ui and the palatal plane. Lower Anterior Dentoalveolar Height (LADH): the vertical distance between Li and the mandibular plane. Upper Posterior Dentoalveolar Height (UPDH): the vertical distance between UMc and the palatal plane. Lower Posterior Dentoalveolar Height (LPDH): the vertical distance between LMc and the mandibular plane

Ramus-corpus ratio: Proportion between ramus height and body length of the mandible. Normal ratio is 5:7.

Magnification of lateral cephalometric radiographs: The cephalograms of this study were taken by the same X-ray machine which had the same film to object distance and object to the source of X-ray. Therefore, there was no significant difference between the magnifications of any cephalogram of the subjects.

Reliability of the measurements: In order to determine the reproducibility of cephalometric landmarks, error of measurements were examined for testing of reliability. A single examiner traced all the measurements where then all tracings double-checked by a professional to verify the accuracy of anatomic landmarks. About 10 cephalograms were selected randomly and retraced after two weeks by the same examiner and finally, paired t-test was performed on mean differences between the first and second measurements.

Statistics for analyzing data: As data collected from analyzing the linear and angular measurements that are mentioned in the study design; statistics were used as a main tool to explain the concepts and interrelations of the variables. The results were calculated by using the SPSS Software (Version 16.0 for Windows SPSS Inc.). Statistical methods for interpreting data in this study were sorted into three parts with respect to different research porpoises:

Paired t-test to check the differences between two varied tracings of single examiner who traced on cephalogram twice with a two weeks interval. Descriptive statistics (mean, standard deviation and range) were calculated for all cephalometric variables and the results tabulated afterwards.

Unpaired t-test was used to calculate the differences between cephalometric values of bimaxillary protrusion subjects with the standard norms which were extracted from many different reference articles. Nevertheless, it should be mentioned that the linear variables were a kind of counterpart analysis which had neither norms nor standard deviations.

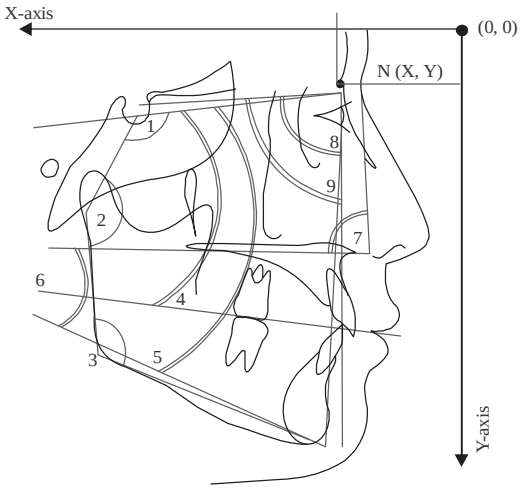

Fig. 4: Angular measurements used in this study (1) Saddle angle, (2) Articular angle, (3) Gonial angle, (4) Occlusal plane angle, (5) Mandibular plane angle, (6) Basal angle, (7) Inclination angle

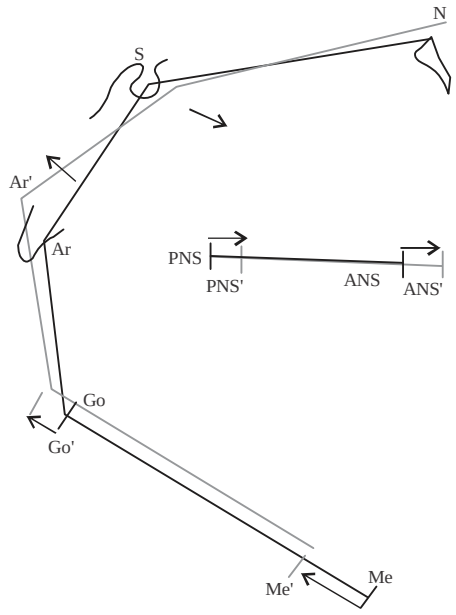

Fig. 5: Skeletal class II pattern with increased saddle angle and rotation of posterior cranial base which leads to forward displacement of maxilla and mandibular retrognathism. This model is not in accordance with normal saddle angle and increased SNB angle in bimaxillary protrusion cases

RESULTS AND DISCUSSION

Test of reliability: The results of the reliability tests are in the worksheet paired t-test of reliability. All tests are not significant as indicated by the p-value or P (T<= t) two-tail that is >0.05. It means that there is no significant difference between the first and second measurements for ten patients.

Unpaired t-test results: Table 1-4 show the statistical comparisons of Filipino subject measurements with standard values. SNA and SNB angles indicated significant increase while the ANB angle was still within the range of skeletal class I malocclusion with a tendency toward a skeletal class II pattern. For linear measurements, the length of maxilla and mandible were much longer than what expected. However, maxilla/mandible and ramus/corpus ratios, decreased dramatically. Inclination angle of Filipino subjects was almost the same as normative value. However, basal, occlusal plane and mandibular plane angles were extremely higher than their respective standards. The actual measurements of saddle angle of the patients had a relatively equal value as compare to the norm. Surprisingly, articular angle was significantly larger than standard. However, the gonial angle had a dramatically decrease in amount. Anterior facial height index and Jarabak index exhibited a lower value than respective norms. Overbite was diminished but the height of anterior mandibular alveolar process and the posterior maxillary dentoalveolar height were significantly higher.

Skeletal sagittal: Increase of SNA angle of bimaxillary and protrusion subjects demonstrates the anteriorly positioning of the maxilla relative to the cranial base. This could be possibly due to two main reasons: forward positioning of posterior cranial base through secondary displacement that pushes the facial complex more anteriorly Fig. 5 and maxillary apical base overgrowth in sagittal plane through the mechanism of primary displacement. Regarding this fact that the Filipino subjects have normal saddle angle (123.76°), it could be postulated that the elongation of the maxilla in the horizontal plane is probably the cause of greater SNA angle Fig. 6. The average of actual measurements of SNB angle was larger than normative value, although, this appears less than its true amount which is due to backward rotation of the mandible that makes the angle lesser in accordance with class I rotated to class II condition. The length of the maxilla was significantly greater than the average which implies the maxillary forward overgrowth in these subjects. Similarly, length of the mandible manifested the same behavior in accordance with anterior cranial base counterpart. However, compare to the maxilla, the mandibular length depicted more increase in size which more or less, creates better balance of the occlusion regarding its severe clockwise rotation.

Dental sagittal: Proclination and protrusion of the incisors were such severe in patients with bimaxillary protrusion that orthodontic/orthodontic-orthognathic

Table 1: t-tests of actual measurements against the norm of skeletal sagittal variables

	Norm		Filipino measurements			
Variables	Mean	SD	Mean	SD	Significance	Actual measurements
SNA	82	2	84.19	2.88	***	Higher
SNB	80	2	80.99	2.65	*	Higher
ANB	2	2	3.52	2.41	***	Higher
Maxillary length	47.23		50.96	3.77	***	Higher
Mandibular length	71.96		80.18	5.38	***	Higher
Maxillo-mandibular ratio	66.59		63.70	5.44	***	Lower
Ramus-corpus ratio	71.5		67.66	4.34	***	Lower

Table 2: t-tests of actual measurements against the norm of skeletal vectorial variables

	Norm		Filipinos			
Variables	Mean	SD	Mean	SD	Significance	Filipinos measurement
Inclination angle	85		83.17	2.74	***	Lower
Basal angle	25		29.66	4.81	***	Higher
Occlusal plane angle	14		20.71	4.68	***	Higher
Mandibular plane angle	32	2	39.83	4.71	***	Higher

Table 3: t-tests of actual measurements against the norm of skeletal vertical variables

	Norm		Filipinos measurement			
Variables	Mean	SD	Mean	SD	Significance	Filipinos measurement
Saddle Angle	123	5	123.76	5.94	ns	Equal
Articular angle	143	6	148.68	9.59	***	Higher
Gonial angle	130`	7	125.88	5.63	***	Lower
Sum of posterior angles	394	6	398.68	5.85	***	Higher
AFH index	45%		43.83	2.06	***	Lower
Jarabak index	63.5%	1.5%	60.92	3.49	***	`Lower

Table 4: t-tests of actual measurements against the norm of dental vertical variables

	Norm		Filipinos			
Variables	Mean	SD	Mean	SD	Significance	Filipinos measurement
Overbite	2.0	1	0.43	1.61	**	Lower
HAMaxA	31.5	1.5	31.38	2.43	ns	Equal
HAManA	45.5	3.5	46.58	3.07	*	Higher
HPMaxA	26.5	1.5	27.32	2.05	**	Higher
HPManA	35.5	2.5	36.13	2.30	ns	Equal

*p<0.05, **p<0.01, ***p<0.001, ns: not significant

correction might be needed in almost all cases. The results of our research about this parameter were similar to the results of other researches that prove this condition could be observed in communities that this discrepancy is prevalent.

Skeletal vectorial: The changes of inclination angle relative to the norm was minimal, therefore, palatal plane steepness in bimaxillary protrusion shows neutral rotation. This is clinically important because of no upward rotation of the plane as the result of excessive vertical posterior growth of nasomaxillary complex which is seen in long face cases with clockwise rotation of the mandible. Basal angle was extremely greater than the standard value that implies the anterior facial hyperdivergence and skeletal open bite pattern. Similarly, the occlusal plane was also steepened and depicted the downward rotation. The measured mandibular plane angle was extremely higher than respective norm that reflects severe clockwise rotation of the mandible and intensity of vertical discrepancy.

Skeletal vertical: The average of saddle angle was relatively equal to the normative value which is in accordance with skeletal class I relationship, so, there is neither aberrant flexion nor abnormal extension of cranial base angle. Articular angle was meaningfully greater than standard which implies posteriorly positioning of the mandible and the tendency for retrognathism Fig. 7. Gonial angle showed lower value in bimaxillary protrusion subjects which seemingly is a compensatory mechanism against great articular angle and severe vertical discrepancy Fig. 7. Anterior facial height index was lower in individuals with bimaxillary protrusion

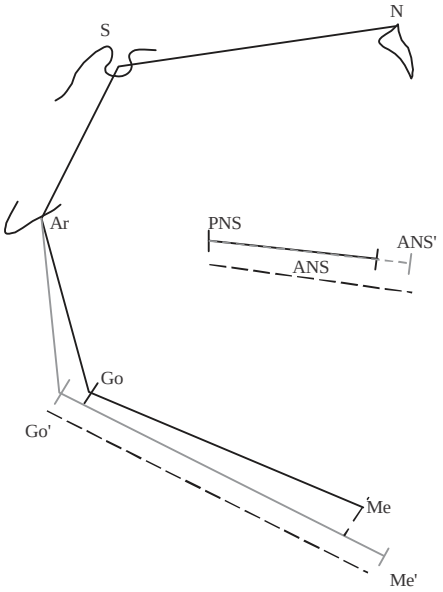

Fig. 6: In this model which seems to be correct, increasing the maxillary and mandibular apical bases is the reason of larger SNA and SNB angles. This feature is more pronounced in mandible. However, increasing the articular angle leads to mandibular retrognathism and reduced SNB angle but elongation of the mandibular apical base compensates this feature

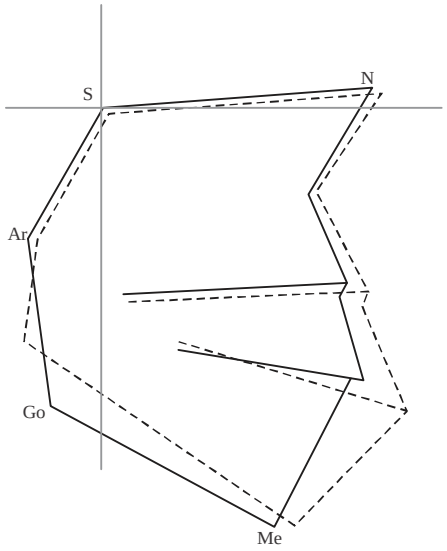

Fig. 7: Schematic superimposition of normal occlusion with good facial balance (black) and bimaxillary protrusion (dotted blue). Take note to the deviations of bimaxillary protrusion cases from normal pattern: increased artiular angle, short ramus, severe rotation of MP angle, elongated upper and lower jaw apical bases and protrusion of maxillary and mandibular dentition. Saddle angle is normal and gonial angle is closed

demonstrating excessive lower face height and hyperdivergence facial type. Lesser vertical posterior growth in comparison with anterior vertical development is the reason of decreased Jarabak index. From ramus/corpus ratio and Jarabak index, we can readily conclude that the ramus is short and this may be one of the reasons of facial hyperdivergence. The results of our research were in contrast with the results of Keating and coworkers who reported a mild vertical discrepancy (Keating, 1985).

Dental vertical: Small vertical overlapping of the incisors is the indicator of possible vertical discrepancy. The average of HAManA is greater than the normative value. Regarding the vertical discrepancy, there is a vertical dento-alveolar overeruption which attempts to reach a normal overbite in this region. HPMaxA is calculated significantly greater than the standard value that implies higher posterior vertical growth of the maxilla which might lead to mandibular plane downward rotation.

After precise analyzing the records of bimaxillary dentoalveolar protrusion cases in Filipino adult patients, it could be said that the extent of the problem is much more than a simple protrusion of the incisors where posterior structures and vertical components are also involved. This makes the treatment plane more complex, therefore, after precise case analysis, other possible solutions like orthognathic surgery like segmental dentoalveolar osteotomy must be considered (Yokoo *et al*., 2002).

CONCLUSION

Adult Filipinos with bimaxillary dento-alveolar protrusion malocclusion suffers from severe discrepancy in both horizontal and vertical planes. Upper and lower jaws overgrow horizontally which leads to increasing the SNA and SNB angles. This might happen due to elongated anterior cranial base counterpart. However, SNB angle could not show its true protrusion because of severe clockwise rotation of mandibular plane. Elongated body of the mandible to some extent, compensated larger articular angle to reach class I relationship. However, flat chin and aesthetic problem are still the major concerns. In vertical dimension, bimaxillary protrusion shows many problematic features including: increasing of mandibular plane angle with hyperdivergent facial pattern, increased articular angle, short ramus, excessive UPAH and reduced overbite. The reason of severe downward and backward rotation of the mandible is probably due to a combination of short ramus and excessive dento-alveolar height of maxillary posterior teeth but not excessive vertical growth

and downward and forward position of nasomaxillary complex. Short ramus might be due to short posterior cranial base.

Bimaxillary dentoalveolar in Filipino patients has a great deviation from the norm in both vertical and horizontal planes; therefore, the need for orthognathic surgery should be taken into account.

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