A CROSS SECTIONAL CEPHALOMETRIC STUDY OF MALE MANDIBULAR GROWTH FROM AGE 16 TO 25 YEARS.

BY

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INTRODUCTION

The use of cephalometric roentgenology as an indirect method of studying bone growth has been utilized by many researchers since its introduction by Broadbent in 1931[1]. In spite of some limitations [2], this technique permits the quantification of increases in size and changes in proportion of the same growing bone (as the mandible) or group of bones, such as the facial complex.

Most of the investigators of facial growth have focused their attention on mandibular changes during childhood and adolescence, but there are very few researchers who have published information about mandibular growth after the age of 16. Little research exists about this age group because early researchers were more concerned with the magnitude and direction of growth during the adolescent growth spurt, when most orthodontic correction takes place. Likewise, the problem of data collection makes such studies difficult.

Since the mandible has the tendency to become more prognathic compared to the maxilla from age 7 to 17[3], thereby causing, in the majority of cases, a decrease in the convexity of the face; and since mandibular length, in absolute dimensions, is one of the slower developing dimensions of the face[4], this bone has been chosen for study.

This research will cephalometrically analyze mandibular dimensional changes that might occur in males after the age of 16, and prior to orthodontic treatment. Hopefully, this information could lead to clues that can help practitioners avoid one of the risks of surgical orthodontic treatment, which is relapse after the surgical procedure.

REVIEW OF THE LITERATURE

The introduction of x-ray cephalometry by Broadbent[1] in 1931 has contributed greatly to facial growth research and treatment planning for more than half a century. Broadbent described a tracing and superimposition technique using successive frontal and lateral films of the same child to reveal growth and developmental changes. He also developed a formula for error enlargement which solves the problem when a nonparallel x-ray beam approaches a convex surface such as the head.

More recently, Richardson[5], Baumrind and Frantz[2] have pointed out another class in errors in head film measurement called "errors of indentification". These errors of identification refer to the process of identifying specific anatomic land marks on head films. In order to minimize these errors Hixon[6] recommended that researchers compute the standard error of the measurement.

Current concepts of craniofacial growth are based mainly on the studies by Bjork[7,8], who some 25 years ago began reporting maxillary and mandibular growth in children with tantalum implants. Statistically, the implant method of studying facial growth on a longitudinal basis has obvious advantages over a serial study using subjects without implants. However, the use of implants is no longer possible.

Most mandibular growth studies are based on changes in mandibular growth at the onset of puberty, plus or minus two years[9,10,11]. The age of completion of measurable mandibular growth is not usually indicated, but can be assessed by close scrutiny of the data presented.

Meredith[12] carried out a longitudinal study on change in mandibular dimension in 14 boys and 17 girls from age 5 to 17 years. Of his five subgroups, one had a pogonion to postgonion dimensional increase of 2 mm from 16 to 17 years of age.

Bjork[13] in his study of variations in the growth pattern of the human mandible shows a graph of condylar growth rate for 45 boys covering the period from 5 to 22 years of age. This graph indicates an annual condylar growth rate of greater than 1 mm per year up to the age of 19. His measurement error, determined on the basis of repeated measurements, was within the limits of $\pm$ 0.5 mm. Both Bjork's and Meredith's articles point out a wide variation in completion of mandibular growth, based on chronological age.

Virginia Knott[14], in her cephalometric study of mandibular growth relative to a cranial base line, found a significant (at P.01) increase in mandibular depth in males between the ages of 17 years and early adulthood (24 to 29 years). Less change was found in the same dimension in females; however, three of four females increased between 1.0 mm and 4 mm. Between the ages of 15 and 17 years, both males and females showed significant increases for the same measurement of mandibular depth.

Anderson, Thompson and Popovich[15] utilized a sample of 111 females from the Burlington Growth Centre to determine any correlation between late mandibular growth and other characteristics such as weight and height. The results showed that the early maturing females, in terms of stature, had greater increments of growth in weight, height and mandibular length between 8 and 12 years, and lesser increments between 12 and 16 years. By age 16 the late maturer caught up to the earlier matures in height and weight, but not in mandibular length. Growth in mandibular length continued past the age at which growth in stature had ceased. Tanner[16], in his book Growth at Adolescence found the same results as Anderson, Thompson and Popovich[15].

Thompson and Popovich[17] evaluated the relationships of the gonial angle and other craniofacial dimensions. One of their conclusions was that the gonial size had little practical significance in the determination of future mandibular growth. Gonial angle size decreased on average from age 4 to 14 years and then remained relatively stable. On an individual basis, gonial angle size tended to be inversely related to mandibular length. That is, a mandible with a more obtuse gonial angle had a shorter mandibular length and a mandible with a more acute gonial angle had a longer mandibular body length. However, this relationship was not clinically significant.

Bjork[18] also described a reduction in the gonial angle with age, but he points out that this decrease is generally not very pronounced due to resorptive remodeling below the angle of the mandible and to periosteal growth on the inferior aspect of the symphisis, which is a compensatory mechanism. In specific cases where the gonial angle decreased the most, the condylar growth direction was more vertical (the compensatory mechanism causing a larger resorption beneath the angulus region). When the gonial angle increased, condylar growth was in a more horizontal direction.

Among the most relevant investigators that explain the mechanism of the mandibular growth processes are Sicher[19] and Enlow[20]. However, much of their work is not related to specific age groups. To Sicher and Enlow the mandible grows in several principal directions simultaneously. As growth of all areas precedes in their particular directions, the various parts of the mandible should relocate in different relative positions. The development of the ramus occurs posteriorly, cranially and laterally in concert with the expanding cranial base, while the mandibular body grows cranially to maintain its relation with the maxilla by extension of the alveolus and teeth. The mandible grows at its upper posterior end, but this growth makes the entire mandible grow down and forward. The two mandibular growth processes responsible for these mechanisms are condylar growth (condylar cartilage) and an accompanying progressive remodeling. Through the proliferation of cartilage the mandible grows longer, higher and wider, while remodeling processes during mandibular growth account for "area relocation". In later adolescent growth the remodeling process involves a small variable degree of deposition or resorption at the chin. Likewise, the ramus remodels to accommodate the third molars.

Many of the early workers[22,23] in orthognathic surgery did not address the problem of late mandibular growth directly. In general terms, their case reports consist of patients over the age of 16 years, if female, or over the age of 17 years, if male.

Even though the amount and direction of late mandibular growth is not predictable on an individual basis, a knowledge of the completion of mandibular growth is crucial to the successful long term results of mandibular orthognathic surgery, as well as the stability to the corrected malocclusion[21].

MATERIALS AND METHODS

The sample consisted of two groups of males chosen from the treatment records of the Oregon Health Sciences University, Department of Orthodontics. The first group was around 16 years of age. The second group was approximately 25 years and above. The data was derived from lateral head radiographs taken mostly with the same Broadbent-Bolton cephalometer, and some with another cephalometer but using the same parameters when taking the film. Routine cephalometric acetate tracing techniques were utilized.

The definitions of the cephalometric landmarks pogonion, menton and articulare are those recommended by the second research workshop on Roentgenographic Cephalometrics[24]. Condylon was the point on the condylar head that was farthest from pogonion. Gonion was obtained by bisecting the angle formed between the mandibular plane and the plane representing the posterior border of the ramus[9].

Where paired landmarks appeared due to the difference in the relationship between the central ray from the x-ray tube and paired structures, both images were traced and the landmark used was a point bisecting the two images were used[25].

The measurements taken for investigation were:

1. Pogonion to condylon, to represent total mandibular length.
2. Pogonion to articulare, as a second and possibly more accurate representation of total mandibular length[26].
3. Pogonion to gonion, to illustrate mandibular body length.
4. Gonion to condylon, a measurement of total posterior mandibular height.
5. Gonion to articulare, a measure of posterior ramus height.
6. Gonial angle, as defined by the intersection of the posterior plane of the ramus and the mandibular plane.

Linear measurements were all affected by a 6-8 percent enlargement. A correction factor was not included in data computations.

Fourteen randomly chosen lateral headfilms were traced on two separate occasions and the replicate measurements were recorded to evaluate tracing error[2]. The same headfilms were measured on two separate occasions to compute the standard measurement error[6].

A statistical analysis of the data was applied according to accepted standard procedure. The mean, standard deviation, and standard error of the mean were calculated for all measurements on the films of the first group of subjects and the films of the older group. A one tailed, independent student "T" test was used to test for significant growth changes between the films of the two mentioned groups.

FINDINGS

The findings and statistical results are presented in table 1 and figure 2. The average age of the first group (young group) was 16 years and one month with a standard deviation of 5 months. The average age of the older group was 25 years and 4 months with a standard deviation of one year and 2 months.

The average total length of the mandible, measured from pogonion to condylon was found to be 123.963 mm on the film of all the young subjects. The standard deviation was 7.9 mm. This dimension increased by 3.394mm to 127.357mm with a standard deviation of 7.748mm on the films of the older subjects. The change was statistically significant.

The distance from pogonion to articulare increased 3.771mm from 113.674mm in the first group to 117.445mm in the second group. This change was statistically significant at the 0.05 level. This distance also proved to be the most accurately reproducible with a standard tracing error of 0.52mm.

Mandibular body length increased from 80.31mm to 82.187mm showing a difference of 1.877mm which was not found statistically significant.

The combined ramus and condylar height measured from pogonion to condylon increased by 2.361mm from 64.203mm to 66.564mm. between the two groups. This was not a statistically significant change at the 0.05 level of confidence. The measurement of ramus height alone from gonion to articulare increased 2.785mm. This was statistically significant at the 0.05 level.

Gonial angle diminished by 1.08° which was not found statistically significant.

DISCUSSION

The technique utilized in growth studies must be carried out with a great deal of accuracy in order to obtain valid results, especially with late growth in which one could expect small increments of change. In this particular study emphasis on reduction of errors was important.

Longitudinal data of implanted individuals was not available. However, every precaution was taken to reduce landmark identification errors. The same individual performed all tracings and located all landmarks in a darkened room, under ideal conditions. The same expert operator took all the radiographs.

All linear measurements were performed in a summa Sketch Digitizer Pad using the software Sigma-Scan by Jandel of Sausalito, California. The standard error of measurement was extremely low, showing the accuracy of this technique.

When examining the mean changes between the radiographs of the two groups, it is evident that the biggest increases are between the distances pogonion-condylon and pogonion-articulare. Both being statistically significant at the 0.05 level. This increment agrees with studies of late mandibular growth in which a forward rotation of the mandible was typical and common in males [28]. At the same time, the above mentioned distances proved to be the most accurate when analyzing the standard tracing error.

Mandibular body length increased by 1.87mm between the radiographs of the young group and the old group. This dimension would be expected to increase by additional remodelling on the posterior border of the ramus, mostly in the inferior third; but the small increase in this study could be due to remodelling of pononion [27]. On the other hand, this dimension had the largest standard error of tracing among the linear measurements.

The mean increases in gonion to condylon and gonion to articulare were above 2mm, the latter being statistically significant the the 0.05 level. Here, according to Enlow we are seeing the effects of the vertical component of condylar growth offset by resorption. Enlow so refers to this process as antigonial notching.

The Gonial angle stayed fairly constant between the two groups of this study showing a slight decrease of 1.08°, but the standard tracing error which was larger (1.84°) must be taken into consideration.

SUMMARY AND CONCLUSIONS

The purpose of this study was to illustrate mandibular growth in males over the age of 16 years. Therefore, the dimensions selected for measurement were chosen because they had exhibited significant change at an earlier age in previous studies.

Head films of 32 subjects whose average age was around 25 years were traced and measured in order to observe changes from head films of another 32 subjects whose ages were about 16 years.

Results showed mean differences between the chosen landmarks from almost 2mm to about 4mm. The increase between pogonion-articulare, pogonion-condylon and gonion to articulare distances proved to be statistically significant at the 0.05 level.

Although many researchers [29, 30, 31] on facial growth have discussed that each person should be appraised as an individual because growth changes do not conform to a set of rules; the results of this project strongly suggest that precaution must be taken into consideration when treating males over the age of 16, when many clinicians would consider these patients had completed their facial growth.

These late mandibular growth changes may be of sufficient magnitude to become clinically evident in the form of relapse of corrected malocclusions or the appearance of new malocclusions after orthodontic treatment or relapse after orthognathic surgery.

BIBLIOGRAPHY

1. Broadbent, B. H. "A New X-ray Technique and Its Application to Orthodontia", Angle Orthod., 1:45, 1931.
2. Baumrind, S. and Frantz, R. "Reliability of Headfilm Measurements", Am. J. Orthod., 60:111, 1971; Am. J. Orthod., 60:505, 1971; and Am. J. Orthod., 70:617, 1976.
3. Land, M. J. "Growth Behavior of the Human Bony Facial Profile as Revealed by Serial Cephalometric Roentgenology", Angle Orthod., 22:78, 1952.
4. Hixon, E. H. Development of the Facial Complex, A.S.H.A. Report, 5:33, 1970.
5. Richardson, A. "An Investigation into the Reproducibility of some points, planes, and lines used in cephalometric analysis", Am. J. Orthod., 52:637, 1966.
6. Hixon, E. H. and Horowitz, "The Nature of Orthodontic Diagnosis", C. V. Mosby Company, St. Louis, 297, 1966.
7. Bjork, A. "Facial Growth in Man Studied with the Aid of Metallic Implants", Acta Odont Scand, 13:9, 1955.
8. Bjork, A. "The Use of Metallic Implants in the Study of Facial Growth in Children: Method and Application", Am. J. Phys. Anthropol., 29:243, 1968.

9. Tofani, M. I. "Mandibular Growth at Puberty", Am. J. Orthod., 62:176, 1972.

10. Maj, G., Luzi, C. "Analysis of Mandibular Growth on 28 Normal Children Follwed from 9 to 13 years of age." Transcripts of the European Orthodontic Society, 38:141, 1962.

11. Traly, W. E. and Savara, B. S. "Norms of Size and Annual Increments of Five Anatomical measures of the Mandible in Girls from 3 to 16 years of age", Archs. Oral Biol., 11:587, 1966.

12. Meredith, H. V. "Serial Study of Change in a Mandibular Dimension During Childhood and Adolescence", Growth, 25:229, 1961.

13. Bjork, A. "Variations in the Growth Pattern of the Human Mandible: Longitudinal Radiographic Study by the Implant Method", 42:400, 1963, supp.

14. Knott, V. B. "Growth in the Mandible Relative of a Cranial Base Line", Angle Orthod., 43:305, 1973.

15. Anderson, D. L., Thompson, G. W. and Popovich, F. "Adolescent Variation in Weight, Height, and Mandibular Length in 111 Females," Human Biology, 47:309, 1975.

16. Tanner, J. M. Growth at Adolescence, Ed. 2, Springfield, Il: C. C. Thomas, 1962.

17. Thompson, G. W. and Popovich, F. "Static and Dynamic Analyses of Gonial Angle Size", Angle Orthod., 44:227, 1974.

18. Bjork, A. and Shieller, V. "Facial Development and Tooth Eruption", Am. J. Orthod., 62:339, 1972.

19. Sicher, H. "Growth of the Human Mandible", Am. J. Orthod., 33:30, 1947.

20. Enlow, D. and Harris, D. B. "A Study of the Postnatal Growth of the Human Mandible", Am. J. Orthod., 50:25, 1964.

21. Baun, A. "Orthodontic Treatment and the Maturing Face", The Angle Orthod., 36:121, 1966.

22. Poulton, D. R. and Ware, W. H. "Surgical-Orthodontic Treatment of Severe Mandibular Retrusion", Am. J. Orthod., 59:244, 1971 and Am. J. Orthod., 63:237, 1973.

23. Proffit, W. R. and White, R. P., "Treatment of Severe Malocclusions by Correlated Orthodontic-Surgical Procedures", Angle Orthod., 40:1, 1970.

24. Salzmann, J. A. Roentgenographic Cephalometrics. J. B. Lippincott Company, Philadelphia,1961.

25. Salzman, J. A. Principles of Orthodontics. J. B. Lippincott Company, Philadelphia,1943.

26. Seward, S. "Relation of Basion to Articulare," Angle Orthod., 51:151, 1981.

27. Kurihara, S. and Enlow, P. "Remodelling Reversals in Anterior Parts of the Human Mandible and Maxilla. "Angle Orthod, 50:98, 1980.

28. Behrents, R. "Normal and Abnormal Bone Growth: Basic and Clinical Research 307-319. Alan R. Liss, Inc. 1985.

29. Moorrees, C. The Dentition of the Growing Child. Cambridge: Harvard Press, 1959.

30. Bjork, A. The face in Profile 2nd ed. Copenhagen: Odontologist Boghandels Forlag, 1972.

31. Hixon, E. "The Norm Concept and Cephalometrics", Am. J. Orthod., 42:898, 1956.

Table I

Statistical Analysis of the films of the young group (group A) and the older group (group B) and the differences (D) between them.

Dimension	N	Mean	S.D.	t.	SEM	Standard Tracing Error	Standard Measurement Error
Pogonion-Condylon (mm)							
Group A	32	123.963	7.9		1.396	0.731	0.153
Group B	32	127.357	7.748		1.369		
	D	+3.394		1.734*			
Pogonion-Articulare (mm)							
Group A	32	113.674	6.652		1.175		
Group B	32	117.445	8.152		1.441	0.520	0.282
	D	+3.771		2.027*			
Pogonion-Gonion (mm)							
Group A	32	80.310	4.771		0.843	1.498	0.210
Group B	32	82.187	5.836		1.031		
	D	+1.877		1.407			
Gonion-Condylon (mm)							
Group A	32	64.203	5.126		0.906	1.223	0.129
Group B	32	66.564	6.325		1.118		
	D	+2.361		1.639			
Gonion-Articulare (mm)							
Group A	32	49.543	5.150		0.910		
Group B	32	52.328	6.698		1.184	1.421	0.140
	D	+2.785		1.864*			

Gonial Angle							
Group A	32	124.907°	8.883°		1.570°		
Group B	32	123.826°	6.986°		1.235°	1.84°	0.245°
	D	-1.081°		0.541°			

* Statistically significant at the 0.05 level.

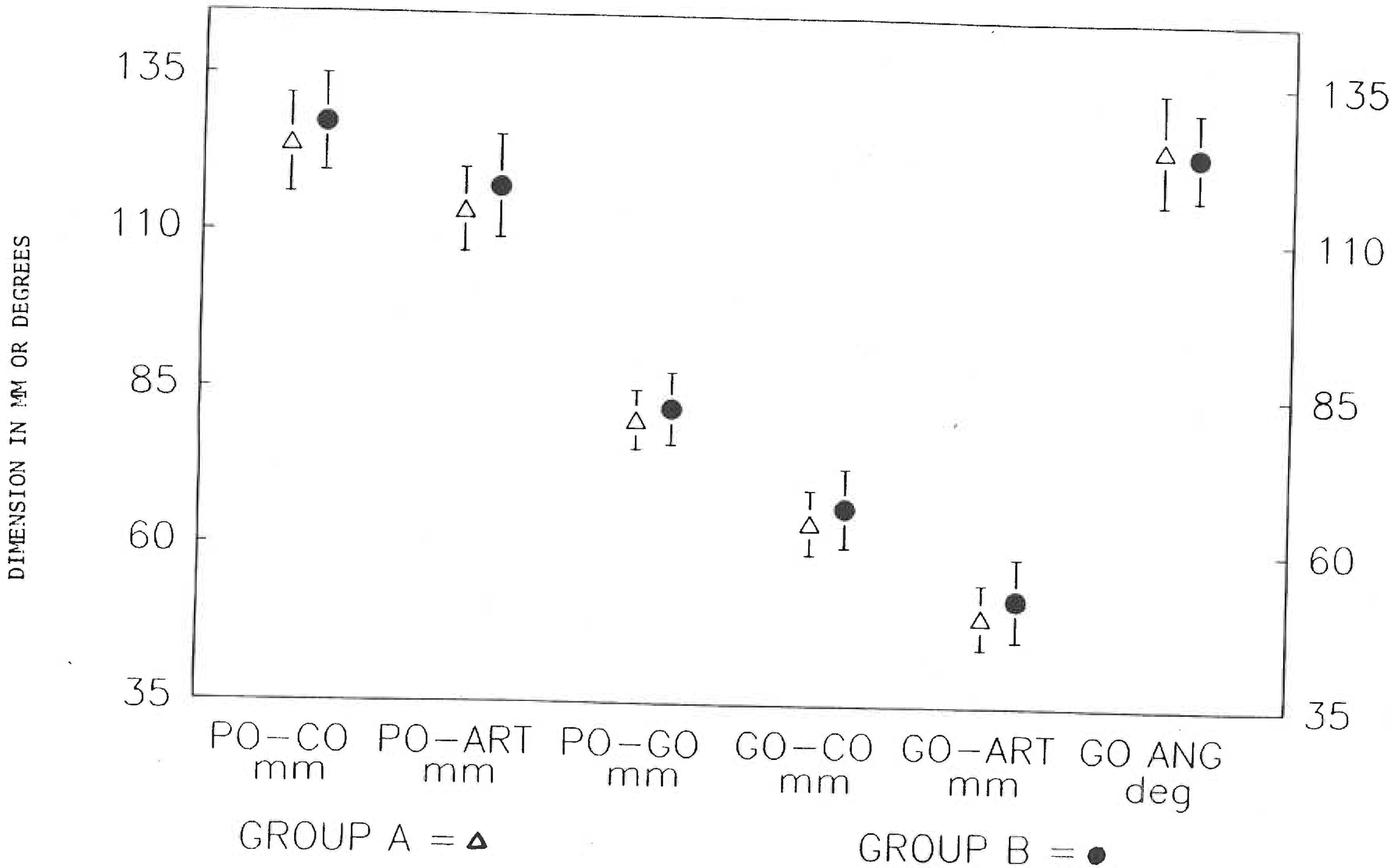

FIG 2: THE MEAN PLUS AND MINUS THE STANDARD DEVIATIONS FOR THE DIMENSIONS INDICATED (N=32).

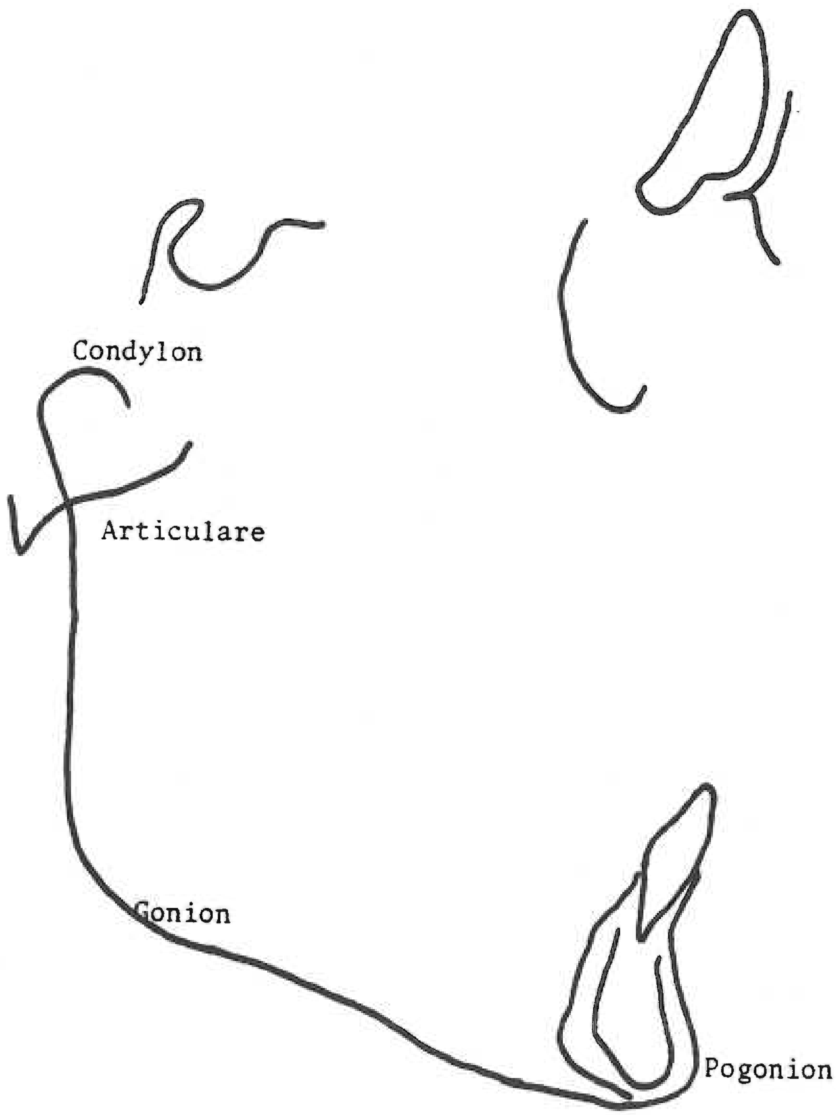

Fig.1: Cephalometric Landmarks.