Chronological Versus Skeletal Age, an Evaluation of Craniofacial Growth

LEONARD S. FISHMAN, D.D.S.

INTRODUCTION

It has long been recognized that an individual's chronologic age does not necessarily correlate well with his maturational age. Skeletally, one may be retarded or advanced in various degrees of deviation from actual chronological age. General rates of skeletal growth have been established for both sexes which demonstrate accelerations and decelerations in growth velocities at various developing maturational stages of growth.

Investigators have studied possible correlations between skeletal growth of the craniofacial complex and general skeletal growth of the body. Orthodontic diagnosis and treatment planning are based largely on an evaluation of a patient's deviation or concurrence with normal cephalometric standards of craniofacial growth. It has been customary for these standards to be based on chronologic age.

The purpose of this study is to investigate the comparisons that exist between chronologic and skeletal ages within a population, to make some judgment as to the reliability of using cephalometric standards based on chronological age as is commonly practiced today, and to study the diagnostic value of using skeletal age for cephalometric evaluation.

REVIEW OF THE LITERATURE

Many investigators have established both positive and negative relationships between growth of the general body and areas of facial growth. Usually these studies involved the relationships of cephalometrically determined facial changes and their comparison to changes in statural height. In many cases both absolute measurement changes and incremental patterns of growth demonstrated significant correlations.

Good correlations were established in a number of studies between growth in statural height and cephalometric measurements involving the bony chin[1-4]. The chin apparently is a good area to focus upon in relating craniofacial growth to skeletal development. Both anthropometric and cephalometric measurements made from the condylar areas to the chin, the cranial base to the chin, and measurements of mandibular body length were significantly correlated with skeletal statural height. Individual variations in skeletal age were more closely related to variations in mandibular growth. Female subjects demonstrated more heterogenicity throughout the adolescent growth period.

Most maxillary and mandibular cephalometric measurements showed a general similarity to statural peak when the investigative samples were evaluated on the basis of skeletal age.[2,4,5,6] Maximum peaks of facial incremental growth curves did not always coincide with statural growth peaks although the patterns in growth velocities were very similar. Several investigators demonstrated a circumpuberal maximum facial growth slightly later than general body height. All studies demonstrated the strong existence of individual variations. Although females demonstrate a chronologically earlier growth rate, the relationships between general skeletal and facial skeletal growth showed no basic sex differences.

When early and late maturing individuals were compared with more average maturing children, differences were found in the relationship of peak

Presented at the May 1977 meeting of the North Atlantic component of the Angle Society.

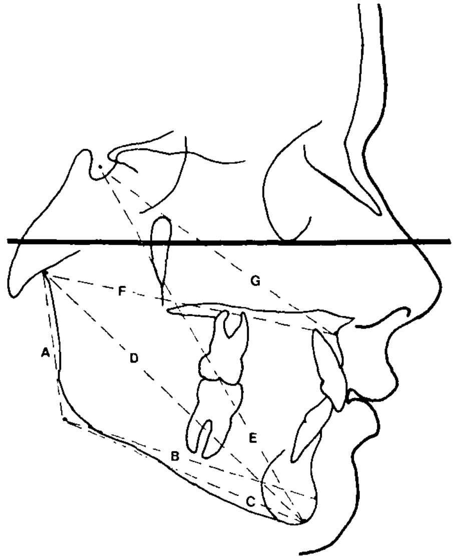

Fig. 1

velocity in statural height to facial velocities.[5,7] Individuals with an advanced skeletal age have an earlier adolescent facial growth spurt. A late maturing individual demonstrates a late facial growth spurt. For average maturing girls the onset of menarche occurred slightly after the maximum peak in statural growth. Late maturing girls initiated menarche well after the maximum peak in body growth and demonstrated more mandibular growth after menarche.[8] Some evidence was presented to suggest that an individual exhibiting advanced skeletal growth is more likely to possess a more favorable dentofacial growth pattern and vice versa.[9]

There have been some investigations that have shown little positive correlation between facial growth and general body growth.[10,11] Differences in results from those studies already cited can usually be attributed to significant differences in research design, such as an evaluation of the face in terms of more general areas involving a multitude of different facial structures and not more commonly used linear measurements that are anatomically more limited.

Methods and Materials

For the purpose of the study a mixed longitudinal series of lateral cephalometric and left hand-wrist radiographs was taken on sixty boys and sixty-eight girls, who were randomly selected. Standing height without shoes was also recorded in centimeters. The individuals studied ranged between the chronologic ages of seven and one half and fifteen, and records were always taken concurrently at approximately six-month intervals. Most of the initial sets of records were taken prior to any orthodontic treatment. Most of the subsequent series of records were taken after active orthodontic treatment was initiated. A total of three hundred and eighty-two sets of records was made.

Seven linear cephalometric measurements were recorded on each film, as illustrated in Figure 1: (A) articulare-gonion (Ar-go), (B) gonion-pogonion (Go-po), (C) gonion-gnathion (Go-gn), (D) articulare-gnathion (Ar-gn), (E) sella-gnathion (S-gn), (F) articulare-point A (Ar-A) and (G) sella-point A (S-A).

Skeletal age determinations were established on the basis of the hand-wrist radiographs. Both the Greulich and Pyle [12] and the Pyle, Waterhouse and Greulich[13] hand-wrist radiographic atlases were utilized for this purpose, together with knowledge derived from a careful study of many individual films.

Each cephalometric measurement was assigned both a chronologic and skeletal decimal age. Measurements associated with each chronologic and skeletal age level were grouped and mean values and their standard deviations were calculated. Mean values and standard deviations were also calculated for the standing-height measurements.

Results

When the total sample was aged both chronologically and skeletally, differences in distribution became apparent. As seen

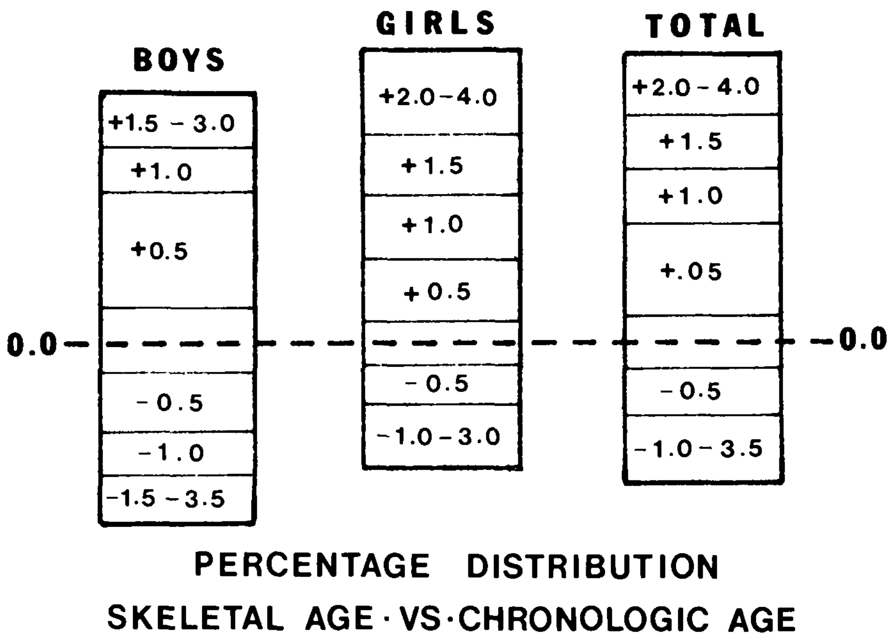

Fig. 2

in Figure 2, only a small percentage of the total sample demonstrates concurrence between skeletal and chronologic ages. This was true also when the male and female samples were evaluated separately. The female group demonstrated approximately twice as many individuals with advanced skeletal age as compared with retarded skeletal age. This is similar to that shown by the total sample population. The boys also had more individuals with advanced skeletal age, although to a slightly lesser degree.

Most of the boys with advanced skeletal age deviated only one half a year from the actual chronologic age. Three quarters of the skeletally advanced boys were within one year of actual chronologic age. Approximately two thirds of the skeletally retarded boys deviated one year or less from actual chronologic ages. The skeletally advanced girls demonstrated a larger deviation from the individual chronologic ages. The girls deviated up to four years in advance of their chronologic age. The accelerated female skeletal distribution was spread rather evenly throughout the four-year period. The skeletally retarded female group exhibited slightly less deviation compared with the male group.

When both the total chronologic and skeletal samples were evaluated in terms of the seven linear cephalometric and statural absolute height measurements, a general concurrence between the two age categories was definitely evident. As seen in Figure 3, in the male sample both of the cephalometric measurements that involved the cranial base point, sella, demonstrated the closest similarity to the absolute statural height growth curve. Both the S-Gn growth curve and the S-A growth curve exhibited very little skeletal vs. chronologic age difference in the respective absolute measurements during the different ages. Both of these measurements showed an increase in steepness of the growth curve beginning at age thirteen and continued in this manner throughout

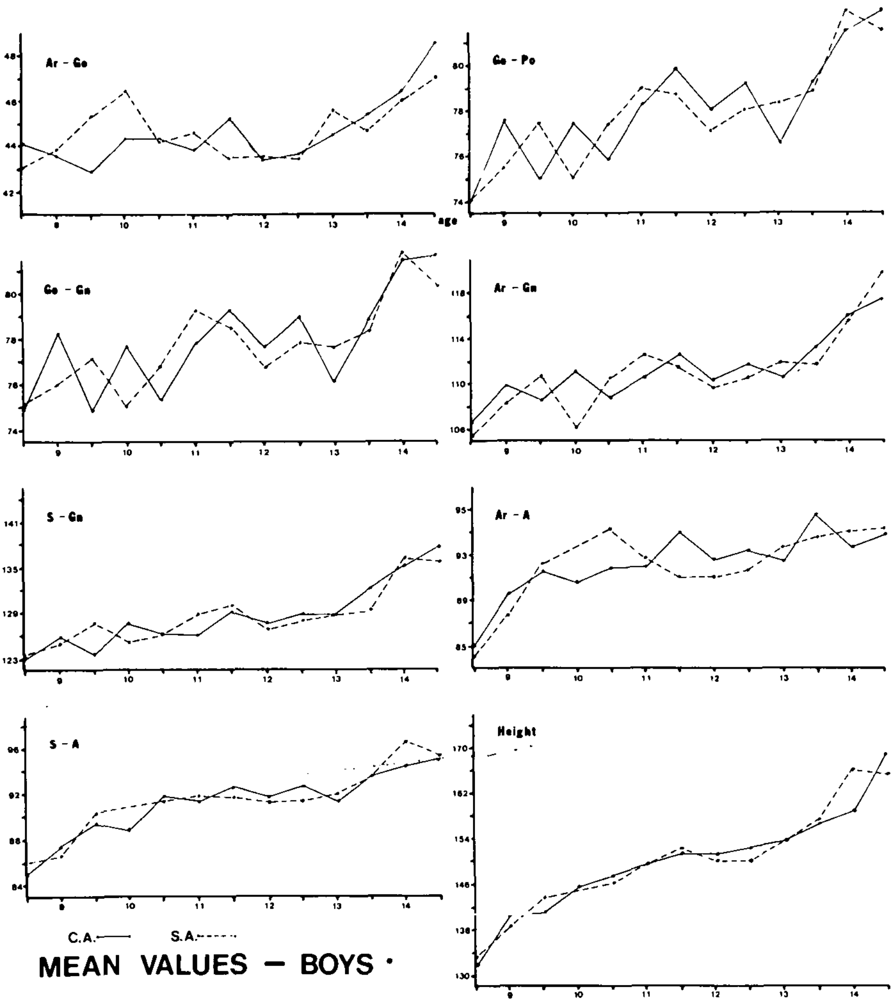

Fig. 3

the growth period studied. This was similar to that seen in the statural height growth curve. Although the remaining cephalometric measurements also demonstrated close similarities between skeletal and chronologic ages, the deviations between the two were slightly more extensive. All the growth curves with the exception of Ar-A demonstrated an increase in steepness beginning at approximately age thirteen. The measurement Ar-A demonstrated a flatter curve throughout the total time span except during the very early years when the curve steepness was quite accelerated. The three measurements involving the angle of the mandible (Ar-Go, Go-Po, and Go-Gn) demonstrated the least concurrence but only during the earlier years.

The girls, as seen in Figure 4, also demonstrated general concurrence between skeletal ages and chronologic ages, although the deviations between the two age categories are significantly more exten-

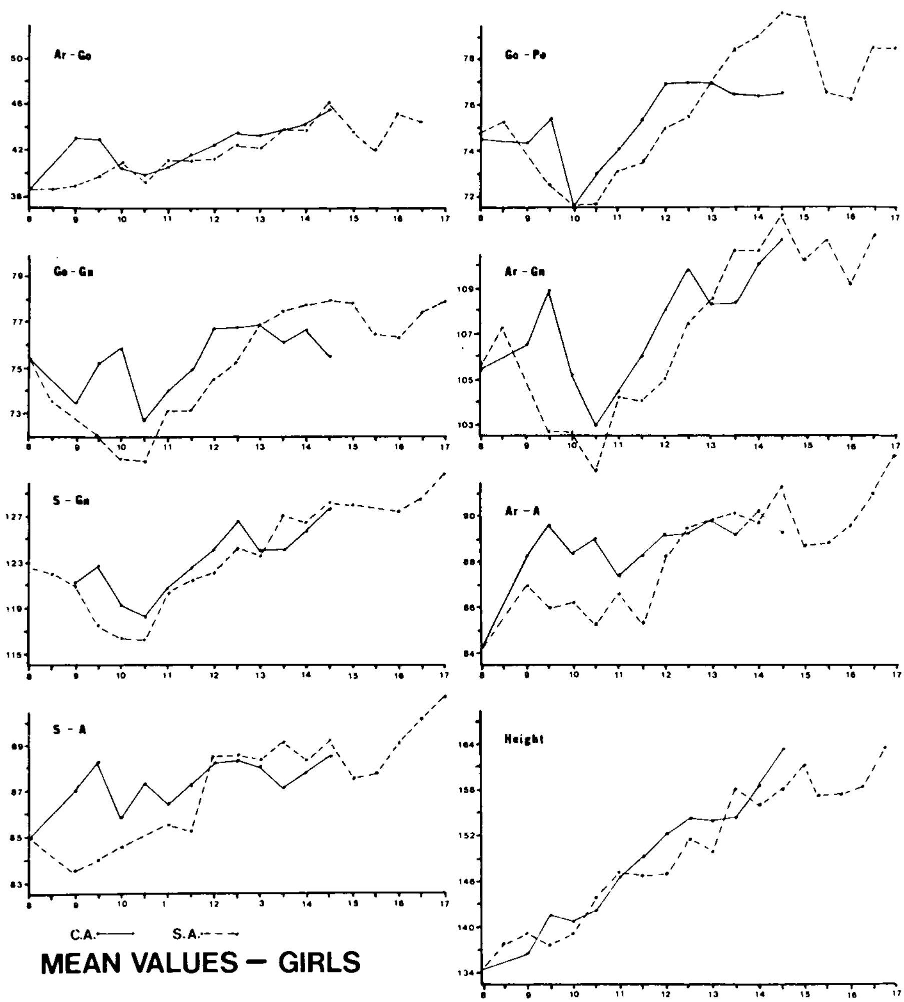

Fig. 4

sive than for the males. Increases in the steepness of the absolute measurement growth curves began at approximately age ten for most of the measurements. There was a tendency for a more leveling off of the curves after approximately age thirteen. With the exception of Ar-Go, all the female measurements demonstrated more deviation between the skeletal and chronologic ages at practically every level. None of the female cephalometric measurements exhibited as much similarity to the statural height curve, as was present in the male sample.

For the investigative results to be most meaningful, it was felt that individual skeletal vs. chronologic age comparisons should be examined. The data become more meaningful and clinically significant when viewed in this manner.

Figure 5 represents a comparison of two girls of approximately the same chronologic age range. The skeletal age of one girl (C.S.) closely compares with her

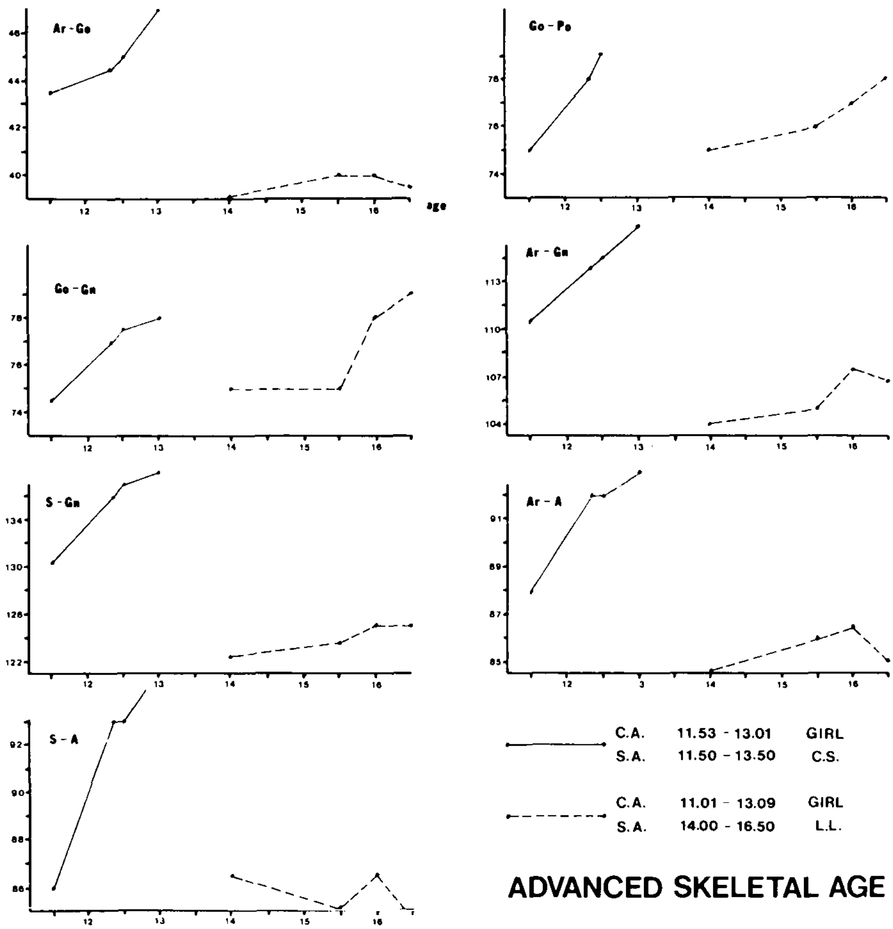

Fig. 5

respective chronologic age. The skeletal age of the other girl (L.L.) is advanced by approximately three years when compared with her respective chronologic age. When facial growth changes are plotted as represented by the seven cephalometric measurements, it becomes very apparent that the respective growth curves demonstrate significant differences.

The girl with advanced skeletal age exhibited less growth during the two year period, as represented by flatter growth curves. This was true for all the facial measurements except Go-Gn. Of particular significance is that the child who demonstrated good concurrence between skeletal and chronologic ages exhibited more rapid growth changes during the age period when this type of pattern is to be expected. Normally during the eleven to thirteen age period girls exhibit a maximum growth velocity. The girl with accelerated skeletal age exhibited facial growth velocities that normally would be expected for a girl of this skeletal age. Girls age fourteen to sixteen and one half usually have already expressed most of their facial growth potential.

Figure 6 demonstrates a comparison of two boys of approximately the same

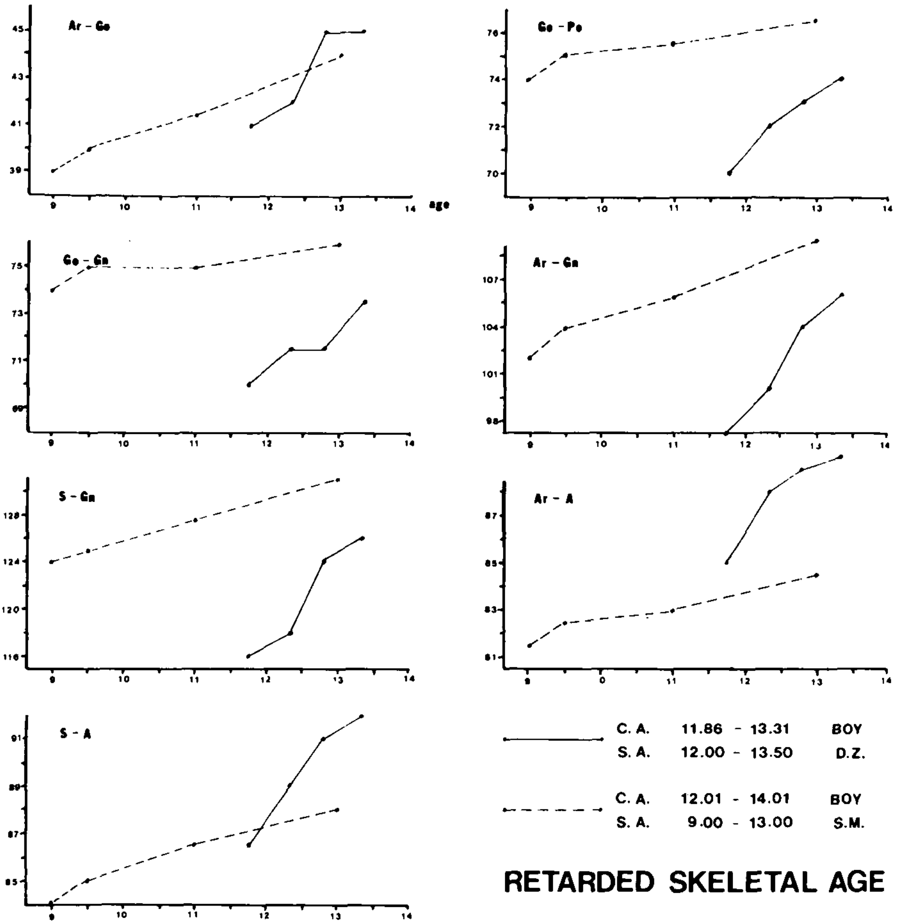

Fig. 6

chronologic age range. The skeletal age of one boy (D.Z.) very closely resembles his respective chronologic age. The skeletal age of the second boy (S.M.) is retarded by approximately three years at the onset of the growth period. The plotted facial growth changes for the two boys depict significant differences.

The boy (S.M.) with a retarded skeletal age demonstrates less velocity in growth of all the maxillary and mandibular structures studied. Of significance is that the child who showed a good relationship between skeletal and chronologic ages exhibited more rapid facial changes at an age period when this type of pattern is to be expected. Normally, boys don't initiate their prepubertal growth spurt much before age twelve or thirteen. The boy possessing a retarded skeletal age demonstrated facial growth patterns that would be expected for a boy of that skeletal age.

Discussion

It was as expected to see such deviations between skeletal and chronologic ages in both the male and female samples. The majority of individuals did not present concurrence between the two ages at most developmental levels. This is very much in agreement with that found by other investigators. Even if allowances are made for geographic variations that sometime exist as to normal developmental skeletal standards for specific chronologic ages, the extent of the discrepancies still is most evident.

This is of particular significance in the clinical practice of orthodontics. The primary purpose behind routine cephalometric evaluations of orthodontic patients is to correlate the actual mechanics of treatment with the biologic aspects of the individual's facial growth and development. The initiation of active orthodontic treatment is too often routinely determined by the chronologic age and the stage of dental development of the individual. Neither of these two factors is very reliable in helping to establish the child's stage of skeletal development. It might be better, and would permit a more objective diagnostic evaluation, if chronologic age was not even considered as a basis to help formulate a treatment plan.

More specifically, treatment procedures such as headgear and chincup therapy might not even be as successful as anticipated if the timing of such treatment is not correlated with the timing of maxillary and mandibular growth. For example, headgear therapy on a twelve year old girl who is either two years retarded or two years accelerated in skeletal growth may yield less than expected results.

Cephalometrically, there often is not much difference in the actual absolute measurements between various chronologic age levels or between different chronologic and skeletal age levels. As clearly noted in this study, the significant difference that exists is not one of absolute numerical values but one of timing. Cephalometric measurements that deviate beyond normal ranges are certainly of importance in establishing the patterns of an individual's growth, but it is the evaluation of the *times* of occurrence of these growth patterns that is of utmost importance.

Of recent years there has been considerable interest in facial growth prognostication for orthodontic patients to the extent that sophisticated computerized programs have been developed to yield very detailed and comprehensive evaluations. No matter how simple or complex the method of growth prediction, the establishment of skeletal not chronologic age would lend itself to more accurate, thereby more clinically, beneficial results.

The orthodontist should put forth the effort to become familiar with the techniques available for determining skeletal age. Evaluation of the hand-wrist film, as utilized in this study, is a relatively practical method of accomplishing this. The education and subsequent delegation of this procedure can be accomplished using auxiliary office personnel, such as is done with cephalometric films.

Conclusions

Skeletal and chronologic ages of both female and male populations were compared relative to the degree of concurrence between the two age-indices at the various age levels. Maxillary and mandibular cephalometric measurements were similarly compared for both sex groups.

Individual's comparisons of facial changes were made relative to their respective chronologic and skeletal ages. The significance of a skeletal vs. chronologic age discrepancy and its relationship to the timing of facial growth was demonstrated. Clinical implications were discussed.

550 E. Genesee St.
Syracuse, N.Y.
13202

Bibliography

1. Johnston, F. E., Hufham, H. P. Jr., Moreschi, A. F. and Terry, G. P.: Skeletal maturation and cephalofacial development, *Angle Orthodont.* 35:1-11, 1965.
2. Hunter, C. J.: The correlation of facial growth with body height and skeletal maturation at adolescence, *Angle Orthodont.* 36:44-54, 1966.

3. Singh, I. J., Savara, B. S. and Miller, P. A.: Interrelations of skeletal measurements of the face and body in preadolescent and adolescent girls, *Growth*. 31:119-131, 1967.
4. Bergersen, E. O.: The male adolescent facial growth spurt: Its prediction and relation to skeletal maturation. *Angle Orthodont*. 42:319-338, 1972.
5. Nanda, R. S.: The rates of growth of several components measured from serial cephalometric roentgenograms. *Am. J. Ortho*. 41:658-673, 1955.
6. Pike, J. B.: A serial investigation of facial and statural growth in 7 to 12 year old children. *Am. J. Ortho*. 50:469-470 (abstr.), 1964.
7. Bambha, J. K. and VanNatta, P.: Longitudinal study of facial growth in relation to skeletal maturation during adolescence. *Am. J. Ortho*. 49:481-493, 1963.
8. Tofani, M. I.: Mandibular growth at puberty. *Am. J. Ortho*. 62:176-195, 1972.
9. Seide, L. J.: The relationship of dento-facial growth and skeletal maturation to malocclusion. *Am. J. Ortho*. 45:801-816, 1959.
10. Rose, G. J.: A cross-sectional study of the relationship of facial areas with several body dimensions. *Angle Ortho*. 30:6-13, 1960.
11. Meredith, H. V.: Childhood interrelations of anatomic growth rates. *Growth*. 26:23-39, 1962.
12. Greulich, W. W., and Pyle, S. I.: *Radiographic Atlas of Skeletal Development of the Hand and Wrist*, ed. 2., Stanford, Calif., Stanford University Press. 1959.
13. Pyle, S. I., Waterhouse, A. M., and Greulich, W. W.: *A Radiographic Standard of Reference for the Growing Hand and Wrist*. Case Western-Reserve Univ., Cleveland, 1971.