Growth Indicators in Orthodontics

Authors

Dr. Rahul Paul
Principal, Head of the Department,
Department of Orthodontics & Dentofacial Orthopaedics
Inderprastha Dental College & Hospital,
46/1, Site IV, Industrial Area Sahibabad,
Ghaziabad, Uttar Pradesh - 201010

Dr. Anamika Bhattacharjee
Post Graduate Student,
Department of Orthodontics &Dentofacial Orthopeadics ,
Inderprastha Dental College & Hospital,
46/1, Site IV, Industrial Area Sahibabad,
Ghaziabad, Uttar Pradesh - 201010

Dr. Deepti Yadav
Professor,
Department of Orthodontics & Dentofacial Orthopaedics
Inderprastha Dental College & Hospital,
46/1, Site IV, Industrial Area Sahibabad,
Ghaziabad, Uttar Pradesh - 201010

Dr. Vandana Gulia
Reader,
Department of Orthodontics & Dentofacial Orthopaedics
Inderprastha Dental College & Hospital,
46/1, Site IV, Industrial Area Sahibabad,
Ghaziabad, Uttar Pradesh - 201010

Published by

HealTalk PUBLICATION

Media House, Zaidi Colony,
Near-New Era School, Eidgah Road,
Qazipara, Bijnor-246701(U.P.)
94 57 61 19 62, ehealtalk@gmail.com

Contributors

Dr. Mudita Gupta
Reader
Department of Orthodontics & Dentofacial Orthopaedics
Inderprastha Dental College & Hospital,
46/1, Site IV, Industrial Area Sahibabad,
Ghaziabad, Uttar Pradesh - 201010

Dr. Ish Sharma
Reader
Department of Orthodontics & Dentofacial Orthopaedics
Inderprastha Dental College & Hospital,
46/1, Site IV, Industrial Area Sahibabad,
Ghaziabad, Uttar Pradesh - 201010

Dr. Ankita Jalani
Reader
Department of Orthodontics & Dentofacial Orthopaedics
Inderprastha Dental College & Hospital,
46/1, Site IV, Industrial Area Sahibabad,
Ghaziabad, Uttar Pradesh - 201010

Dr. Rashtrabhushan
Reader
Department of Orthodontics & Dentofacial Orthopaedics
Inderprastha Dental College & Hospital,
46/1, Site IV, Industrial Area Sahibabad,
Ghaziabad, Uttar Pradesh - 201010

Dr. Ankush Bhardwaj
Lecturer
Department of Orthodontics & Dentofacial Orthopaedics
Inderprastha Dental College & Hospital,
46/1, Site IV, Industrial Area Sahibabad,
Ghaziabad, Uttar Pradesh - 201010

Dr. P. Tarishma
Lecturer
Department of Orthodontics & Dentofacial Orthopaedics
Inderprastha Dental College & Hospital,
46/1, Site IV, Industrial Area Sahibabad,
Ghaziabad, Uttar Pradesh - 201010

Dr. Rhythm Kharbanda
Lecturer
Department of Orthodontics & Dentofacial Orthopaedics
Inderprastha Dental College & Hospital,
46/1, Site IV, Industrial Area Sahibabad,
Ghaziabad, Uttar Pradesh - 201010

Headquarters
Media House, Zaidi Colony,
Near-New Era School, Eidgah Road,
Qazipara, Bijnor-246701(U.P.)
90 27 63 74 77,
ehealtalk@gmail.com
Corporate Offices
#967/21C, HBC, Express House,
Faridabad-121001, Haryana
Website: www.healtalk.in

Inquiries for bulk sales may be solicited at: ehealtalk@gmail.com

Growth Indicators in Orthodontics
First Edition: 2026
ISBN ***978-81-959272-5-4***

Dr. Rahul Paul

Dr. Rahul Paul, a teacher, a mentor and an orthodontist has been in the field for more than two decades. Presently, he is working as Principal and Heading the Department of Orthodontics and Dentofacial Orthopaedics in Inderprastha Dental College and Hospital, India. He is specialised in aligners, myobraces, functional habit correction, lingual orthodontics and surgical orthodontics.

He completed his B.D.S. and M.D.S. from ABSM Institute of Dental Sciences, Mangalore. With an experience over 20 years, he has numerous publications under his name in various national and international indexed journals. He is also part of various professional study groups and organizations. He has been awarded with various awards, which includes the Best IDA Thesis Award (1999), Best outgoing Orthodontic student ICD Award (1999), Best Appreciation Award ICD (2007) and the Best principal Award 2022 (Global Educators Fraternity).

Dr. Deepti Yadav

Dr. Deepti Yadav who is currently a professor in Inderprastha Dental College, Sahibabad, India has done her B.D.S. and M.D.S. from Goa Dental College. She has also been an integral part of Lady Harding Medical College & Smt. S.S.K. Hospital for more than a year. With an academic experience of more than 10 years, she has been a guide to a number of students for both undergraduate and postgraduate students.

She has published articles which are indexed in both National and International journals under her name. With a clinical expertise of about 15 years, she has been awarded with Best Graduate Award (2003), Best Orthodontist Award in 2019 by Eminent Healthcare Awards, Best Cosmetic Dentist in 2021 by National Healthcare Service Excellence Awards and also the Emerging Researcher by Cynodent International Awards in 2022. She is a Reviewer in Journal of Clinical Dentistry, Advances in Science Technology and Engineering Systems Journal and Journal of Engineering Research and Sciences.

Dr. Vandana Gulia

Dr. Vandana Gulia, has completed her B.D.S. from Dayananda Sagar Dental College, Bengaluru M.D.S. from Coorg Institute of Dental Sciences, Virajpete. Her clinical specialties include MBT system, Tip Edge Plus, Clear Aligners, Accelerated orthodontics and many other surgical and comprehensive topics in the field of Orthodontics and Dentofacial Orthopaedics. Her contribution has been a part of various articles and also a book title Orthodontic Archwires. She has been awarded as best Emerging Orthodontist of the year by Cynodent International Awards in 2022.

Dr. Anamika Bhattacharjee

Dr. Anamika Bhattacharjee who has completed her B.D.S. from kalinga institute of dental sciences , KIIT UNIVERSITY , Bhubaneswer from 2012 to 2017. She has practiced a general dentist for 2 years and gained specialist skill in rotary, implants. Participated in numerous State and National Conferences and Conventions. Attended National and International Webniars conducted by Indian Othodontic Society in topics like biomechanics, myofunctional appliances, Aligners, Accelerated orthodontics . Currently she is a resident of Department of Orthodontics and Dentofacial Orthopedics at Inderprastha Dental College & Hospital.

Contents

1
Chapter

Introduction

Rahul Paul, Anamika Bhattacharjee

CHAPTER OUTLINE

- What are growth indicators?
- Why is it important?
- Relevance in orthodontics.

Genetic and racial diversity and environmental influences have a marked effect on the rate of development of the prepubertal child and adolescent with the result that chronological age need not necessarily reflect the progress which an individual has made toward physiological maturity. A more accurate assessment of physical development may be made by the radiographic examination of the calcified structures of the hand and wrist from which the degree of maturity of individual bones may be assessed and the skeletal age determined by comparison with published radiographic standards[1].

Positive and negative relationship were established between growth of the general body and areas of facial growth and these includes the cephalometrically determined facial changes and their comparison to changes in statural height where in many cases both absolute measurement changes and incremental patterns of growth demonstrated significant correlations. Both anthropometric and cephalometric measurements made from the condylar areas to the chin, the cranial base to the chin and measurements of the mandibular body length were significantly correlated with skeletal statural height. Individual varia-tions in skeletal age were more closely related to variations in mandibular growth. Female subjects demonstated 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. Maximum peak of facial incremental growth curves did not always coincide with statural growth peaks although the patterns in growth velocities were similar. Females demonstrate a chronologically earlier growth rate and the relationship between general skeletal and facial skeletal growth showed no basic sex differences[2].

It is presently agreed that some general factor of body maturity exists that results in the tendency for a person to be advanced or delayed as a whole. Skeletal maturity which is the most commonly used index is closly related to sexual and somatic maturity. Girls who are skeletally advanced also mensturate early. Simmon and Greulich[3] demonstrated this relationship and confirmed that age of menarche is more closely related to skeletal maturity than chronological age and since skeletal maturity and the appearance of the ulnar sesamoid are related, correlations between the appearance of the ulnar sesamoid and menarche are also consistently high investigations.

Staging off human skeletal development has been assessed using physiological parameters including peak growth velocity in standing height, pubertal marker, radiographic assessment of bone maturation, chronological age, staging of dental development. Peak growth velocity in standing height is the most valid representation of rate of overall skeletal growth and it forms a useful historic longitudial measure of an individual's growth pattern but has little predictive value for future growth rate or percentage of total growth remaining. For this reason, an indication of the maturation level of an individual is necessary to predict future growth. Longitudinal measurements used to calculate peak standing height growth velocity do provide the gold standard to access the validity of growth predictors. Dental development indicators are not reliable predictors of an individual's stage of skeletal development because there is wide variation among individuals in the timing of the pubertal growth spurt, chronological age also cannot be used in the evaluation of adolescent growth as Hagg and Taranger [4]reported a two year sex difference for the beginning , peak and end of the pubertal growth spurt in standing height for males and females and in addition they also reported an individual variation of approximately six years in each growth event in both sexes. Furthermore, environmental factors may influence timing and rate of skeletal development.

Hellman(1932)[5] was one of the first to recognise the importance of developmental age, grouping children by eruptive stage rather than chronological age but the extrinsic factors had caused variation in eruptive time and sequence making it largely unsatisfactory as a indicator of maturation level.

Cephalometric radiography has enabled research workers to relate growth of facial components to that of various other body structures. Nanda[6] in a longitudinal study of several facial dimensions, formulated distance and velocity curves to illustrate the changes he observe where he found a general circum pubertal increase in growth velocity, though the timing of both the onset and peak rate of growth were different for the various dimensions of the same child and circum pubertal acceleration in facial growth occurred approximately nine months after that in body height. Hunter[6] in his study concluded that maximum facial growth was coincident with maximum height growth in the majority of subjects in his study.

Maturational development embodies the overall biologic progression through life and in the growing years, indicators of the level of maturational development of the individual provide best means for evaluating biologic age and the associated timing of skeletal growth. Adolescence is a period demonstrating varying increase -ments of skeletal change occuring in widely disparate age periods. The system of skeletal maturation assessment has been presented as a reliable means of utilising hand –wrist radiographs for this purpose. Eleven skeletal maturity indicators have been previously outlined and described. The Skeletal maturuty indicators make it possible to judge an individual's relative timing of maturation - whether it is early , average or late and comparison of boys and girls on maturatioal time scale shows no sexual differences in the percentages of completed incremental growth at the same SMI levels, regardless of chronologic age[7.]

Ulnar sesamoid bone is one of five sesamoid bones in the adult hand and lies at the metacarpophalangeal joint of the thumb. It is the only consistent ossification centre in the hand that appers near puberty and due to its time of appearance, it has been utlilized as a possible indicator of puberty. Appearance of sesamoid to easily identifiable adolescent phenomena such as menarche or increased height acceleration is well establised with the sesamoid appearance preceding menarche by two and one half years on average and maximum height increase by about one year in girls and nine months in boys according to Bjork and Helm[6].

Lamparski (1972)[8] utilized the cervical vertebrae and found them to be as reliable and as the hand- wrist area for assessing skeletal age. He developed a series of standards for assessment of skeletal age for both males and females. This method has the advantage of eliminating need for an additional radiographic exposure since the vertebrae are already recorded on the lateral cephalometric radiograph.

An understanding of growth events is of primary importance in the practice of clinical orthodontics. Maturational status can have considerable influence on diagnosis, treatment goals, treatment planing and the eventual outcome of orthodontic treatment. Clinical decisions regarding use of extraoral traction forces, functional appliances, extraction versus nonextraction treatment or orthognathic surgery are atleast partially based on growth considerations. Prediction of both the times and the amounts of active growth, especially in the craniofacial complex, would be useful to the orthodontist[9].

References

1. Chertkow. S, Dip. H, Fatti . P.The relationship between tooth mineralisation and early radiographic evidence of the ulnar sesamoid. Am J Orth. October 1979;Vol 49,No.4.
2. Fishman. L. S .Chronological versus skeletal age, an evaluation of craniofacial growth. Am J Orth. July .1979; Vol 49 No. 3.
3. Demirjian et al .Interrelationships among measures of somatic , skeletal, dental and sexual maturity. AJODO 1985;88:433-438,
4. Flores-Mir C, Nebbe B, Major.W P .Use of Skeletal Maturation Based on Hand-Wrist Radiographic Analysis as a Predictor of Facial Growth: A Systematic Review .Angle Orthod 2004;74:118–124.
5. Johnston et al .Skeletal maturation and cephalofacial development. Am J Orth. Jan1965;vol 35, No.1.
6. Pileski. R. C. Awoodside.D.G. James.G.A, Relationship of the ulnar sesamoid bone and maximum growth velocity. Am J Orth April 1973.vol 43.No.2.
7. Fishman .L.S Maturational patterns and prediction during adolescence. The Angle Orthodontist., July 1987.
8. O'Reilly M.T,Yanniello.G.J . Mandibular growth changes and maturation of cervical vertebrae-A longitudinal cephalometric study.The Angle Orthodontist, April 1988.
9. Moore .R.N, MoyerB.A, DuboisL.M . Skeletal maturation and craniofacial growth- AJODO, July 1990;98:33-40.

2

Chapter

History

Deepti Yadav, P Tarishma

CHAPTER OUTLINE

- Evolution
- Recent Advances

Todd T.W. (1931)[1] took a series of periodic hand wrist radiographs for grouping children in Cleveland, Ohio, USA and published his initial data in 1937.The standard time period was three month after birth to sixteen years in girls and nineteen years in boys at which dates symbols or determinators of skeletal maturity provided by growing shaft surfaces, epiphysis and cartilage bones of the wrist.

Greulich W. Pyle (1959)[2] compiled the radiographs in the Atlas of skeletal development of hand and wrist which was further revised in 1959 and 1972. The purpose of this Atlas is to provide a series of x-rays of the hand and wrist as standards of skeletal development which may be used to determine the developmental status of a child. It was written in response to the need, emphasized by the demands of well-baby clinics and school health programs, for more precise and less variable measurements than height, weight and age.

Nanda R.S. (1955)[3] analysed the growth patterns of human face as studied from the serial cephalometric roentgenograms of 15 white person 10 males and 5 females aged between 4-20 years. Each series of roentgenograms were studied in terms of both curve of growth and curve of relative increment. The purpose of the study was to determine the overall growth change in various dimensions of face. The results of the investigation revealed the circumpubertal maximum in height and the facial dimensions generally occur close to each other. On the whole, the cicumpubertal maximum in the facial dimensions has a tendency to occur slightly later than in body height.

Bambha J.K. (1959)[4] in a longitudinal study of the craniofacial skeleton in relation to body height found that there is a definite circumpubertal growth spurt of the face and that it occurs just after the spurt in body height. The various facial dimensions studied were found to follow the same curve of growth of stature. The time of onset and peak of growth spurt was said to show individual variability.

Lewis A.B., Garn S.M. (1960)[5] stated no close relationship could be shown between skeletal maturation and mineralization of the lower premolar and 2nd molar teeth. They interpreted that while it is obvious that the teeth are not unusually accelerated or retarded in their development then growth is faster or slower, the explanation for the relationships between the dental formation and general maturation requires further investigation.

Tanner J.M. (1962)[6] found that the annual height (stature) growth increments in children reached a plateau at 16 yrs in boys and 14 years in girls and it was thought that these are the changes at which frontal sinus enlargement ceased.

Garn; Rohmann (1962)[7] found a high correlation among assessments from hand wrist, the elbow, the shoulder, else hip, the neck and the foot. He also demonstrated moderate correlation between the time of ossification of sesamoid and the time of menarche and of epiphyseal union.

Bjork (1966)[8] found that maximum pubertal growth occurs at approximately the same time for upper face, the mandible and body height.However, the growth ceases at different ages and complicates the prediction of residual growth.

Hunter (1966)[9] conducted a study on 25 males and 34 females in which the chronological age, skeletal age and height of 59 subjects were recorded in the month of their birth dates and at six month interval approximately 7 years through adolescence. The skeletal age was determined from hand wrist radiographs with the use of 1950 edition of Greulich and Pyle standards. The annual cephalograms were taken at the ninth month of the chronological year upto approximately 13 years after which the radiographs were usually taken during the month of subject's birthday. It was found that the skeletal age range at the onset of pubertal growth period in height was found to be one half the chronological age ranges in males. He found that little difference was seen between the chronological and skeletal age range at the onset in females and females enter the pubertal growth period 2.38 years earlier than males.

Bjork A., Helm S. (1967)[10] conducted a study in 32 boys and 20 girls selected from Danish population in whom all stages of physical maturation examined had been reached and determined and reported that the onset of ossification of ulnar sesamoid of the first metacarpophalangeal joint is closely associated to the adolescent spurt in statural height. A close correlation was found between the age at maximum growth in body height and age when ossification of ulnars metacarpophalangeal sesamoid of thumb occurred and also in girls, the age at the menarche. The sesamoid did not ossify after maximum pubertal skeletal growth and it usually ossified one year before. It was concluded that in clinical orthodontics, both skeletal and dental maturation should be registered.

Tweeds C. H (1969)[11] Developed the diagnostic facial triangle as a valuable adjunct in the analysis and treatment of malocclusion. The attainment of the FMIA requirement of the diagnostic facial triangle as a result of treatment procedures involves a working knowledge of the following: 1. The ability to measure and compare available and required arch lengths. 2. How to make the cephalogram correction to determinc total archlength discrepancies. 3. Preorthodontic tooth guidance, including serial extraction of teeth. The growth trend classification, Types A, B, and C. 5. Anchorage preparation, first, second, and third degrees. 6.The necessity for instituting mechanical therapy in the treatment of Class I and Class II malocclusions that will maintain the normal inherent forward and downward growth vector of the middle and lower face.

Bjork A. (1969)[12] A survey is presented of experience with the implant method in the study of facial growth, with particular emphasis on prediction of mandibular growth rotation. Three methods of prediction are discussed. (1) A longitudinal method, which consists of following the course of development by annual x-ray cephalograms, (2) A metric method, which aims at prediction based on a metric description of the facial morphology at a single stage of development (3) A structural method is described by which it may be possible to predict, from a single cephalogram, the course of rotation, where this feature is marked. This method is based on information gained from implant studies of the remodeling process of the mandible during growth.

Tofani M.I. (1972)[13] said that growth of mandible does continue after menarche and the onset of fusion in the distal phalanges of finger were found to be highly correlative with menarche.

Lamparski (1972)[14] utilized cervical vertebrae and found it to be more reliable and valid than hand wrist radiograph for assessing the skeletal age. He developed a standard for assessing the skeletal age for both male and female by using five vertebrae (second to sixth vertebrae). This method has the advantage of estimating the need for an additional radiographic exposure since the vertebrae are already recorded on lateral cephalogram.

Ricketts M. R. (1972)[15] purpose of this paper was to explain a method of finding the arcial growth of the mandible, to enumerate some of the uses of the principle and to explore changes in the clinical concepts .Essence of his principle is: a normal human mandible grows by superior-anterior (vertical) apposition at the ramus on a curve or arc Ricketts enumerated the evolution of this principle and the step-by-step approach to ascertain the arcial growth of the mandible, including the method of locating Xi point, and also the projections of the maxilla, dentures and soft tissue culminating in the latest reincarnation of his projection technique.

Chapman S.M. (1972)[16] for the first time used a standard size dental film to assess the development of metacarpo-phalangeal joint and evaluated the correlation of adductor sesamoid with the adolescent growth spurt in a group of subjects in South Wales. In his study 70 males and 70 females aged between 10- 16 years were evaluated longitudinally and it was found that the appearance of adductor sesamoid bone occurred regularly in accordance with the development of first metacarpophalangeal joint and the onset of ossification of the sesamoid takes place at the time of adolescent spurt in statural height begins. The duration of later is observed to coincide with the duration of the sesamoid in development.

Demirjian, Goldstein and Tanner (1973)[17] describe a new method for estimating dental maturity or dental age by reference to radiological appearance of seven teeth on left quadrant of mandible. Each tooth is given a point value according to the stage of development, rather than the change in size. Nine stages O, A to H were defined for each tooth mineralization stage. The sum of the individual points on all teeth gave the dental maturity directly.

Sarcar S., Kapoor D.N., Ray R.K., Sarin P.K. (1974)[18] conducted a study to establish the norms for order of appearance of carpal bones at different age levels among girls and boys. They reported that the sequence of appearance of different carpal bones was different for both sexes and also that all the carpal bones appeared significantly earlier in girls than boys.

Roche A.F., Lewis A.B. (1974)[19] studied the sex differences in the elongation of cranial base during adolescence. The two samples of South Western Ohio white children included 58 boys and 41 girls who were radiographed within one month of each birthday. The age range of the serial radiographs varied between children but extended from atleast two years before and two years after peak height velocity (PHV). It was reported that the pubertal growth spurts in stature occurred about two years later for boys than girls.

Johnston.E.L (1975)[20] introduced a simplified approach to prediction in the form of a “forecast grid,” which shows average increments of growth per year for the points nasion, A, B, nose, posterior nasal spine, and maxillary first molar. Five-year forecasts were completed by hand using the tracings of thirty-two patients, which were part of the University of Michigan Elementary School Growth Study (average interval: 7.5 to 12.5 years). The forecasts were superimposed on the outcome using a standard S-N orientation. The author stated, “The grid did not perform too badly,” explaining that the predictions were not much worse than would be expected from an analysis of cephalometric error.

Schulhof. J.R et al (1975)[21] evaluated the ability of Ricketts' long-term forecast, the Ricketts short-range predictions and the Johnston grid system and average increments from Sella- Nasion to accurately predict the growth at A point, Pogonion, Ricketts' Xi point, tip of the nose and mandibular molar position. The records of fifty untreated patients were used to perform ten-year predictions using the various methods.The authors found that the Johnston grid was the least accurate, and the Sella- Nasion average increments method was an improvement over the Johnston grid. The computerized Ricketts short-range prediction method showed a 10-20% improvement over the average increments, and finally, the computerized Ricketts long-term forecast was found to be the most accurate, being 21% more accurate than the Ricketts short-range method and 56% more accurate than the Johnston grid system.

Greenberg Z.L., Johnston E. L (1975)[22] evaluated the accuracy of Ricketts' computerized long-term arcial forecast. One hundred untreated subjects, each having lateral cephalograms at ten and fifteen years of age were included. Twenty subjects were traced and five-year arcial forecasts were completed. The remaining 80 subjects were used to generate independent estimates of the mean changes for the various cephalometric measures tested. The authors found that there was no significant difference between the computerized method of prediction and the average change in the population. They therefore concluded that this sophisticated method was unable to individualize the subjects and that more simplistic methods would prove equally satisfactor

Grave K.C. Brown T. (1976)[23] studied fourteen ossification events in the hand and wrist in relation to the age of peak growth velocity in body height in 52 boys and 36 girls. The subjects were aborigines enrolled in a longitudinal growth study. Records obtained included family histories, body measurements, dental casts, cephalometric roentgenograms, roentgenograms of hand and wrist and photographs of the head. For the study, the records of children which recorded birthdates were selected. A number of ossification events were studied on serial hand wrist film. It was found that the peak height velocity and the ossification events occurred in aborigines at about the same age as in Caucasian children. The results indicated that the ossification events can be used by orthodontist to assess a child's growth activity.

Popovich.F,Thompson.W.G. (1977)[23] used records of 120 males and 90 females from the Burlington growth center to produce cephalometric templates for six different ages for females and seven different ages for males between 4 and 20 years of age. Based on the longitudinal growth direction of the anterior part of the mandible, these templates were separated into vertical, horizontal and average growth patterns to be used as a practical approach to orthodontic case analysis and craniofacial growth

Chertkow S., Faiti I.P. (1979)[24] from the records of one hundred and forty children of Caucasian origin concluded that the calcification of the adductor sesamoid was closely related to the completion of root mineralization of mandibular canine prior to apical closure and no significant sex differences were noticed. Also calcification of adductor sesamoid commences two years earlier among South African girls when compared with boys at mean age of 11.3 years.

Houston W.J.B. (1979)[25] conducted a study on 68 boys and 58 girls of ossification events and bone ages in the prediction of the timing of pubertal growth spurt. Records were obtained at six monthly intervals until the first signs of secondary sexual characteristics appeared and then every three months including hand wrist radiograph were taken in standardized fashion and measurement of stature was done as described by Tanner (1962). He concluded that prediction of timing of pubertal growth spurt using hand wrist x-rays could be helpful in planning growth modification treatment.

Grave K.C., Brown T. (1979)[26] presented four case histories to illustrate how carpal radiographs may be used as a diagnostic guide to provide information on developmental status, including growth potential around puberty. This could also be used as a guide to determine the onset of adolescent growth spurt and hence provide the clinician with a diagnostic and planning aid to optimize treatment efficiency. Information of this type can be valuable when the optimal timing of orthodontic treatment is determined.

O'reilly M.T. (1979)[27] stated that maximum increment in maxillary length occurred before, as well as after menarche. Onset of epiphyseal – diaphyseal fusion and peak growth in height was weakly correlated with onset of epiphyseal – diaphyseal fusion and menarche.

Chertow S. (1980)[28] studied the records of 197 patients (159 white and 38 black), taken from files of orthodontic practice and Orthodontic Department of School of Dentistry, University of Witwaterstrand. Panoramic dental and water oblique radiographs of left mandible and maxilla together with radiographic views of left hand and wrist, taken from the clinical records of these patients were examined. He found that the completion of root formation of mandibular canine tooth prior to apical closure may be used clinically as a maturity indicator of the pubertal growth spurt with a similar degree of confidence as some of the other indicators described on the hand wrist radiographs.

Smith R. (1980)[29] demonstrated a consistent sex difference in the relationship between the skeletal age and facial growth. He concluded that although hand wrist radiographs may provide some information of value to the orthodontist with male patients, the radiographic exposure is not justified for most females
.

Bishara S.E. (1981)[30] did a study on 20 males and 15 females aged between 8-17 years to examine the changes in mandibular dimensions and relationships as they relate to standing height which is one indicator of skeletal maturation. Records were taken from Facial Growth Study conducted at the University of IOWA consisting of lateral cephalogram.

It was concluded that the treatment of antero-posterior discrepancies should be initiated as soon as the orthodontist believes that treatment is indicated rather than wait for pubertal growth spurt since the magnitude and timing of such events in any person is highly unpredictable.

Tanner J.M., Whitehouse R.H. (1982)[31] introduced a method in which bone age can be determined by assessing a weighed score to the developmental stage of each of 20 bones used in hand wrist, the bone age thus will be the total score for the radiographs.

Fishman (1982)[32] developed a system of skeletal maturation indicators (SMI) using four stages of bone maturation at six anatomic sites on hand and wrist radiograph. Both longitudinal and cross sectional samples were evaluated in the study. Longitudinal data was derived from Denver Child Research Council study that was active between the years 1927 and 1967. Physical measurements of 170 females and 164 males were evaluated monthly upto 3 months of age at 3 month interval upto 6 months of age then semiannually until adulthood. Cross sectional samples were obtained from treatment records of patients undergoing orthodontic treatment. More than 1400 hand wrist radiographs of the patients were collected for the study. Sample was divided into male and female sub sample groups corresponding to 11 SMIs. The system uses the stages of bone maturation, all found at 6 anatomical sites located on thumb, third finger, first finger and the radius.

Nanda S.K. (1983)[33] stated that the prediction of adolescent spurt is most important relative to the timing of treatment. He further said that, when a child's skeletal age is advanced in comparison to the chronological age, less growth could be anticipated, conversely if the child's skeletal age was found to be behind his/her chronological age, then a greater growth potential should be assumed and incorporated into the treatment plan.

Skieller V.,Bjork A.,Hansen T L.(1984)[34] A study was done to estimate the possibility of predicting the direction and the amount of growth rotation of the mandible on the basis of morphologic criteria observed on a single profile radiograph at pubertal age. The sample consisted of twenty-one persons in whom the actual mandibular growth rotation was determined from metallic implants over a 6-year period at around the time of puberty. The four variables which, in combination, gave the best prognostic estimate (86%) of mandibular growth rotation in this sample. The concordance between the predicted and the observed growth changes is illustrated graphically for each person.

Demirgian A. (1985)[35] evaluated an interrelationship among 5 measures of physiologic maturity for 50 French Canadian girls – 1) menarche 2) Peak Height Velocity (PHV) 3) 75% of skeletal maturity 4) appearance of ulnar sesamoid 5) 90% dental development and concluded that peak height velocity, skeletal development and sexual maturation are closely associated. Skeletal and somatic maturities belong to the same system. They pertain to mesodermal tissue regulated by pituitary and gonadal secretions which influence ossification of epiphyseal cartilage and result in the growth of long bones. Dental development and its low association with skeletal, somatic and sexual maturity may be attributed to the independence of the common controlling mechanism controlling the other factors. The interpretation is supported by the ectomesenchymal derivation of the dentition and is independent of somatic / sexual maturity.

Heinrich U.E. (1986)[36] said skeletal development is an important maturity indicator during childhood. The skeletal age determination is helpful for the diagnosis of disorders of growth and development as most hormones have specific effects on skeletal maturation. Disharmonic centers of hand and wrist have been said to be found in certain disorders of development.

Letite H.R., O'reilly M.T. (1987)[37] conducted a study on 20 females and 19 males subjects from the files of the Bolton – Brush foundation to investigate whether skeletal age assessment using 1st, 2nd & 3rd fingers of hand were valid as those using whole hand. Two maturity indicators, the sesamoid and the epiphyseal, diaphyseal stages of ossification were evaluated. The results showed that the maximum deviation occurred during the time of epiphyseal – diaphyseal fusion when growth was nearing its completion and therefore, they were of no clinical importance. The advantage of this method was that the three fingers could be incorporated in the lateral cephalometric radiograph, thus eliminating the need for additional radiograph.

Shigemi Goto (1987)[38] studied x-ray films of the distal phalanx of first digit observing the ossification as an index to study development during growth and observed that the thickness of epiphysis and diaphysis increased proportionately with age. Complete fusion of diaphysis and epiphysis occurring at the age of 13 years is observed to be 82.9% in girls whereas only 14.9% in boys. Growth and development of the girls is observed to be approximately 2 years ahead of boys and also the growth in height during adolescence was said to be complete almost before total fusion of diaphysis and epiphysis. Any growth after that was considered minimal.

Sierra A.M. (1987)[39] in her study on 153 orthodontically treated Caucasian children aged 8-12 years selected from the case records of the department of orthodontics at University of Detroit School of Dentistry. Treatment records included a pretreatment hand wrist radiographs and a Penelipse radiograph using a fixed object film distance on the same machine. The radiographs were assessed based on maturity indicators for individual bones developed by Greulich and Pyle. It was found that the correlation between the calcification of teeth (dental age) and skeletal age as assessed by eight ossific center method were quite high. She also said that the lower cuspid correlated better with each of the 8 ossific centers than any of the other several teeth studied.

Houston W.J.B (1988)[40] Mandibular growth rotations are a reflection of differential growth in anterior and posterior face heights. Growth in posterior face height depends on the vertical components of growth at the middle cranial fossa and at the condyle. It is suggested that growth in anterior face height is greatly influenced by growth of the cervical column and the resulting differential growth of the muscles, fascia and other soft tissues that pass between cranium, mandible, hyoid bone and shoulder girdle. The effects of variations in head posture are superimposed upon these primary determinants.

Moore R.N., Moyers B.A., Dubois L.M. (1990)[41] did a study on 47 girls aged 10-15 years and 39 boys (11-16 years) from Bolton Brush data base to assess the relevance of handwrist radiograph to craniofacial growth and clinical orthodontics. Serial annual cephalometric radiographs, handwrist radiographs and standing height measurement were obtained and it was concluded that the relationship between acceleration and deceleration in growth of specific craniofacial dimensions and statural height or skeletal maturity may be used as a factor for diagnosis and treatment planning for an individual case.

Lewis A.B. (1991)[42] analyzed associations between dental and skeletal maturity in 694 untreated children. Dental ages were obtained by comparison with Bolton standards and skeletal ages were assessed using the Greulich-Pyle atlas and concluded that the difference between the dental and skeletal ages was as large as 36 months; the difference was less than 6 months in fewer than 40% of the children.

Rassouw P.E., Lombard C., Harris A.M.P. (1991)[43] conducted study on skeletal growth patterns of 103 subjects with class I and class II malocclusions and was cephalometrically analyzed as advocated by Rickets et al to assess abnormal rickets. A significant correlation between maxillary length, mandibular length, symphysis width, condylar length and frontal sinus size was reported to exist on a lateral cephalogram. He also proposed that frontal sinus could be used as an additional indicator while predicting mandibular growth.

Mitani H., Sato K. (1992)[44] in sample of 33 Japanese girls aged 9-14 years compared growth characteristics of the mandible during puberty with growth characteristics of the hyoid bone, cervical vertebrae, hand bone and standing height. He found that the mandibular growth may show unpredictable, random variation in timing and amount whereas the size of mandible, body height, hand bone and cervical vertebrae are all correlated strongly with each other. At 14 years, the strong correlation between the mandible and both the hand bone and cervical vertebrae began to weaken, although other correlation remains strong. The body height showed a strong correlation with

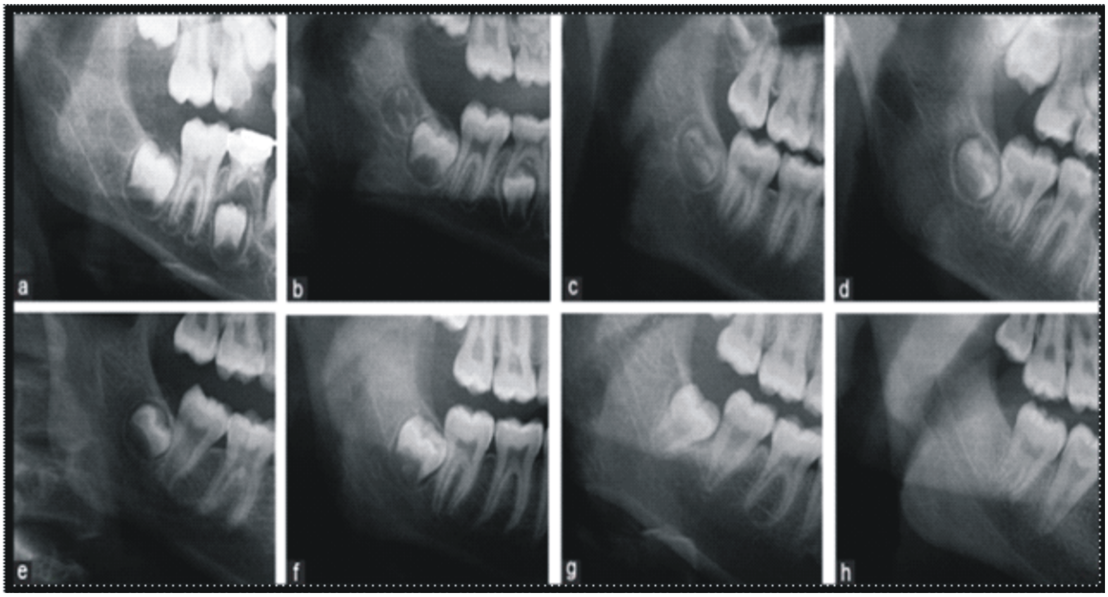

Figure 17 Developmental Stages of Third Molar.

At stage G: Most show adductor sesamoid

- Capping of the diaphysis of middle and distal phalanges of the third finger.
- Capping of the proximal phalanx of the fifth finger.

At stage H:(indicating apical closure)

- Fusion of the epiphysis to their respective diaphysis.

- **Discussion:** The relationship between skeletal maturity and peak adolescent height velocity (PHV) is well established.
- Bjork found that capping of epiphysis of the third phalanx was very closely related to the age of pubertal maximum growth velocity.

Stage H -The apical end of root canal is completely closed.

- ***Hagg and Taranger*** [18] showed the PHV was more closely related to the skeletal stages of the third phalanx than to the maturity stages of the radius or adductor sesamoid.
- Other investigators have shown that capping of the third phalanx coincides closely with PHV.
- Canine stage F indicates the initiation of puberty.
- The timing of stage G ,which coincides with the eruption of the canine into the oral cavity, occurs approximately 1 year before the PHV in boys, but only 5 months before the PHV in girls.
- The presence of the adductor sesamoid. It is indicative of PHV. The intermediate stage between stages F and G should be used to identify the early stages of the pubertal growth spurt.

Type C Growth Trend

- Lower face is growing downward and forward more rapidly than the midface.
- Decrease in ANB angle. Incidence – 60 % of the population (Fig 3).

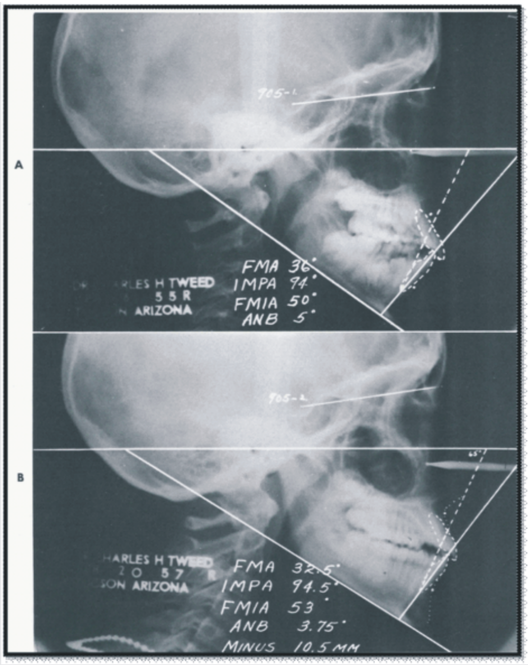

Figure 3- Type C Growth Trend.

- Irregularity in the mandibular incisor area as the lower face in growing anteriorly the lower insiors cutting edge engage with the lingual surface of the maxillary incisors. So, this can result into 2 things either lower insior lingual tipping or upper incisor labial tipping.
- Retention can be a problem -
  - Upper incisor proclination, if orbicularis oris is weak.
  - Lingual tipping of lower incisors, if orbicularis oris is strong.
  - Lower anterior crowding.
- Mandibular cuspids to cuspid lingual bar, maxillary retainer with labial bar.
- Prognosis- Excellent. T/t time 10- 15 months[2,3].

References

1. Shelly Jain et al. Tweeds Philosophy - A Review. Indian Journal of Orthodontics and Dentofacial Research, October-December 2017;3(4):198-206.
2. Charles H. Tweed , Clinical Orthodontics - Volume 1.
3. Björk A, Skieller V. Normal and abnormal growth of the mandible. A synthesis of longitudinal cephalometric implant studies over a period of 25 years. uropean Journal of Orthodontics, Volume 5, Issue 1, February 1983, Pages 1–46.

9

Chapter

Bjorks & Jhonston's Forecast Grid

Rahul Paul, Deepti Yadav

CHAPTER OUTLINE

- Site of Implant Placement
- Maxillary Rotation
- Mandibular Rotation
- Forecast Grid

- ***Bjork[1] Study*** (1969).
- He started his study in 1951.
- Sample size of 100 children between the age group of 4 – 24 yrs.
- He studied mandibular inclinations by placing implants at various sites of mandible.
- Examination were done on -
- The sites of growth and resorption in individual jaws, individual variation in direction and intensity.
- He disagreed the concept that the given intermaxillary relation remained static through out life.
- There was considerable variation in the development of facial form and intermaxillary relation.
- Need for growth assessment rose – to design the treatment / evaluate the problem before the completion of growth.

Site of Implant Placement

- In mandible, it is inserted-

1. In symphysis in the midline below roots.
2. In body of mandible—one below first premolar and second below first molar.
3. Outer surface of ramus in level with occlusal plane[2] (Fig 1).

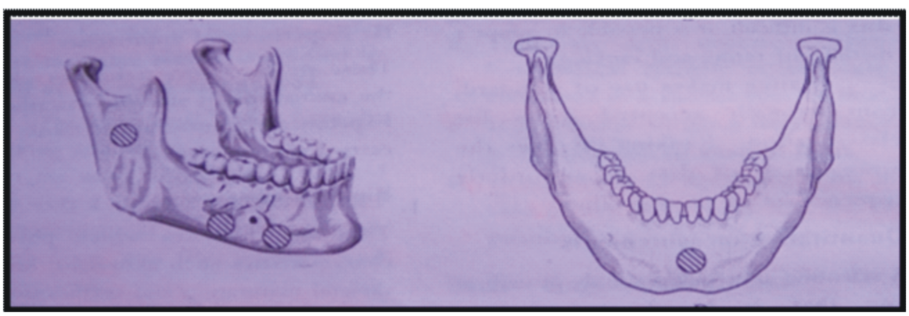

Figure 1 - Site For Implant Placement in Mandible

construction of an arc in the time 1 composite through the three points Pm, Xi, Dc. By extending this arc the size increase was produced but not enough bending in form resulted.

A second arc through coronoid process produced the deepest curve, (Fig 2)

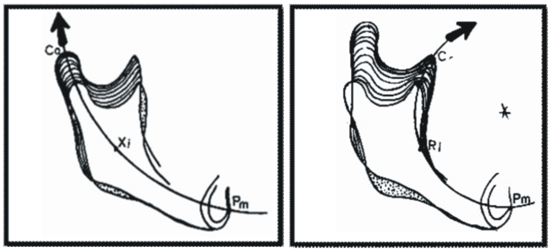

Figure 2- Experimental arc with computer composite of a 40 patient sample five years without orthodontic treatment. This arc through condyle was too open for average, but typical of class iii.

Experimental arc with computer composite of a 40-patient sample five years without orthodontic treatment. It was explored by using the tip of the anterior border of the ramus at it's the same Pm point. The extension of the segment of a circle was too small in excessive bending of the mandible when growth was employed for a projection.Out of the two arcs one is straightening the mandible too much and the other is bending the mandible too much. A true arc of growth therefore must lie somewhere in the mandible between the condyloid and the coronoid process and between the ramal center and its anterior border. By establishing a halfway point between Xi and R1 points (the center and anterior border of the ramus) and using the distance from this point to Pm as a radius of a circle, an arc could be produced.

In addition a radius selected from this point would increase with size of the mandible and a progressive increase or a changing arc or ultimate spiral shape would result. Growth therefore could not be represented as a simple segment of a circle.

Attention therefore was directed to a mandible where stress lines were seen in the outer and inner plates. The lines exhibited the design of the mandible and was hoped that these functional stress lines would also yield some clues, regarding the possible development of the mandibleas it is known that stress tend to run parallel to bone trabeculae. The load being carried in the superstructure of a bone thus can be analyzed.

By the analysis of compression, extension, shear and torsion, these lines begin to fit a pattern. Close examination of mandible confirmed the convergence of stress line at the protruberance menti.

The stress lines seemed to swing downward and then upward and backward through the external oblique ridge. However great attention was directed toward the medial side. On the internal aspect even greater forking was noted than was seen on the lateral side. The stresses here followed the mylohyoid ridge upward into a thick mass to terminate at a Y shaped bony prominence which was almost the center of the upward and forward quadrant of the ramus on the lingual aspect and, in fact, might be the base of the tuberosity of mandibular growth.

Enucleation of Third Molar

He has practiced lower third molar enucleation in about 100 cases. With a long range forecast, he projected the mandible of the child all the way to his prospective maturity. The occlusal plane and erupted position of the lower first molar are included in the mandibular prediction (Fig 11). This means that we

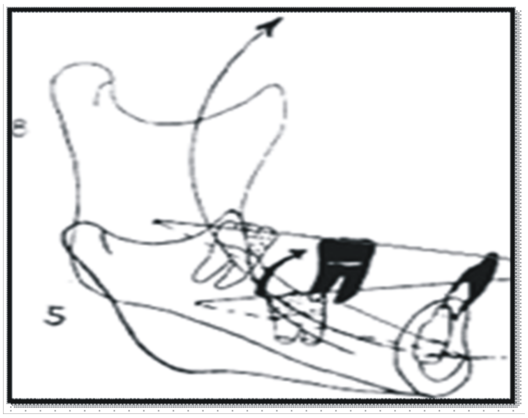

Figure 11 - Arc of growth as theory of superpositioning reveals the lower arch to develop upward and forward making space for the second and third molars.

can be relatively sure how much space is going to be available posterior to the first molar if we do nothing. Some remodeling may take place, but average implant studies show a curve only slightly more open than shown here. Problems arise clinically in the posterior area, particularly in the lower arch during orthodontic treatment and sometimes without treatment.

He states that as we intrude lower incisors with a utility arch, we push them downward into a stronger portion of the lower lip, and the lip resists their forward movement. The result is the lower molars being moved backward and over the top of a developing lower second molar. The third molar lies over the top of the distal margin of the second molar and now traps the second from front and back (Fig 12).

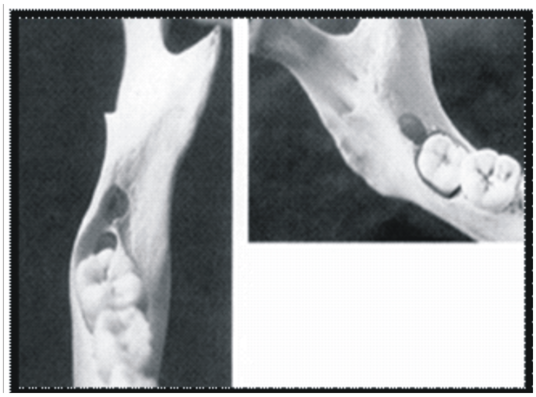

Figure 12 - Two views of developing third molar, showing the open follicle on the lingual side of the mandible.

Now, with the diagnosis from the long range forecast and with the prospects of this kind of treatment, we arrive at the amount of space that will be available for the second and third molar by maturity with a given treatment, or no treatment. When the prognosis of the third molar is less space than 50% behind the external ridge, he recommends its removal.The anatomy of the developing follicle of the lower third molar shows that it is an open bony window on the lingual aspect of the mandible.Development level about age 9, but this stage may come in a range from 8 to 12 commonly. He contemplated this situation for a long time, and finally concluded that the only thing to do was to go in and spoon out the follicle. Dr Ricketts[1] said that with the discovery of an arc as a working principle for the growth of the mandible, he was coming close to the true meaning of the word prediction.

The objective is “to foretell the future”, to master the unknown[7].