Growth and Development of Cranio – Mandibular Structures

Growth

- According to KROGMAN , growth is an "Increase in size, change in proportion and progressive complexity"
- According to MOYER`S "Quantitative aspect of biologic development per unit time"

THEORIES OF GROWTH CONTROL

- It is a truism that growth is strongly influenced by genetic factors, but it also can be significantly affected by the environment, in the form of nutritional status, degree of physical activity, health or illness, and a number of similar factors.

Exactly what determines the growth of the jaws, however, remains unclear and continues to be the subject of intensive research.

Three major theories in recent years have attempted to explain the determinants of craniofacial growth:

(1) bone, like other tissues, is the primary determinant of its own growth;

(2) cartilage is the primary determinant of skeletal growth, while bone responds secondarily and passively;

(3) the soft tissue matrix in which the skeletal elements are embedded is the primary determinant of growth, and both bone and cartilage are secondary followers.

- The major difference in the theories is the location at which genetic control is expressed.
- The first theory implies that genetic control is expressed directly at the level of the bone, and therefore its locus should be the periosteum

- The second, or cartilage, theory suggests that genetic control is expressed in the cartilage, while bone responds passively to being displaced. This indirect genetic control is called epigenetic.

- The third theory assumes that genetic control is mediated to a large extent outside the skeletal system and that growth of both bone and cartilage is controlled epigenetically, occurring only in response to a signal from other tissues.

Sutural Dominance Theory (Sicher)

- Sicher introduced that sutures were causing most of growth
- Primary event in sutural growth connective tissue proliferation between the two bones.
- This creates the space for oppositional growth at the borders of the two bones.

- The connective tissue in sutures of both the nasomaxilary complex and vault produced forces which separated the bones.
- The theory held sutures, cartilage and periosteum all responsible for facial growth and assumed all were under tight intrinsic genetic control.

- Shortcomings of Sutural theory It is clear now that sutures are not primary determinants of growth. Two evidences in support are: 1)Sutures & periosteal tissues lack innate growth potential,proved by transplanting a suture

2)Growth at sutures responds to outside influences,as compression and tension.

- For eg. If cranial or facial bones are pulled apart at sutures, new bone fills in and if suture is compressed the growth will be impeded. Sutures are thus areas that react-not primary determinants. Thus sutures are growth sites, not growth centres.

- Growth Center: Those areas of craniofacial skeleton that have: tissue seperating capabiltiesand innate growth potential not influenced by external factors e.g.Synchondrosis and nasal septal cartilage.

- Growth Site: Locations at which active skeletal growth occur but as a secondary ,compensatory effect lacking direct genetic influence effected by external influences. e.g. sutures and periosteum.

Scott's Hypothesis

- Held that cartilaginous portions of head, nasal capsule, mandible and cranial base dominate facial growth.
- Specifically emphasized how the cartilage of nasal septum paced the growth of maxilla.
- Sutural growth came in response to growth of other str. including cartilaginous structures

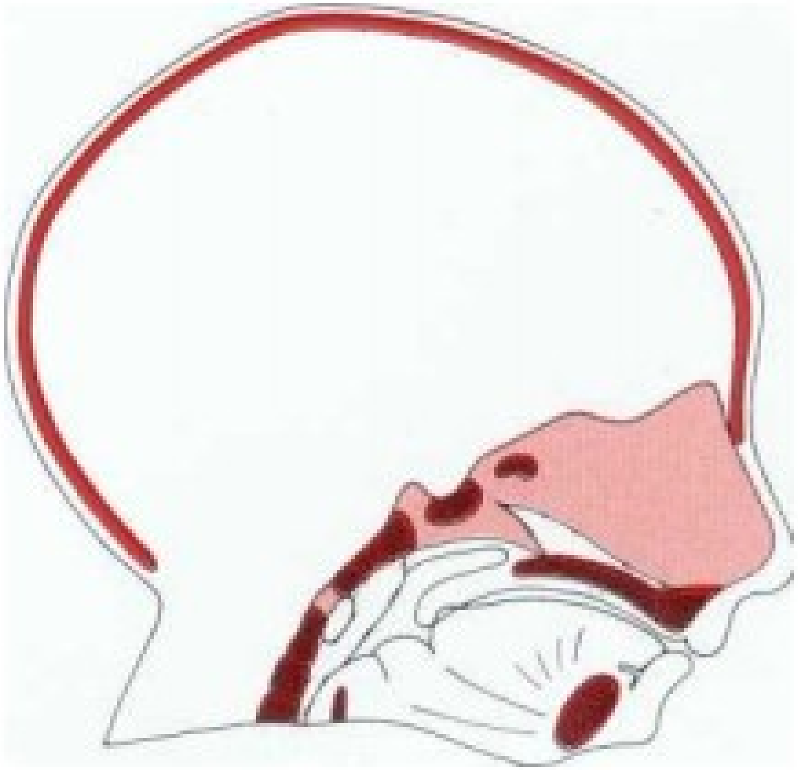
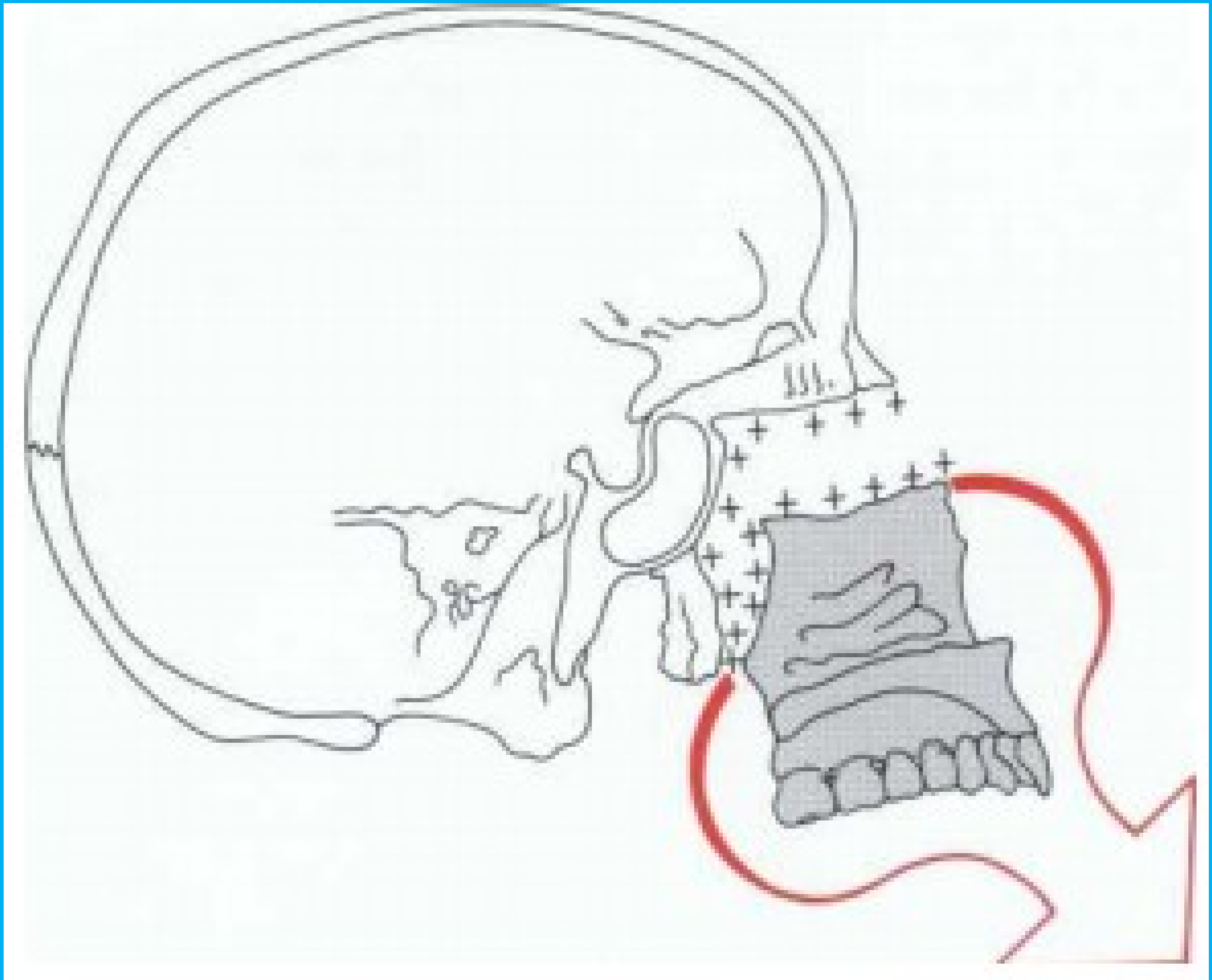


FIGURE 2-34 Diagrammatic representation of the chondrocranium at an early stage of development, showing the large amount of cartilage in the anterior region that eventually becomes the cartilaginous nasal septum.

Growth at nasal septum causes downward & forward translation of maxilla

- Growth of maxilla on basis of Scott's theory nasomaxillary complex grows as unit that cartilaginous nasal septum serves as a pacemaker for maxillary growth
- cartilage growth leads to forward and downward translation of maxilla. sutures which serve as reactive areas respond by new bone formation leading to growth.



Experiments to verify Scott's

- theory Two kinds of experiments carried out to test the theory:

  1. Transplantation experiments

  2. Removal of cartilage.

  In transplantation experiments not all skeletal cartilage act same when transplanted

- Epiphyseal plate of long bone continued to grow in new location. Spheno-occipital synchondrosis also grows when transplanted, but not as well. Nasal septal cartilage found to grow nearly as well as others. No growth found when mandibular condyle transplanted.

- In cartilage removal experiments, Extirpating a young rabbits septum causes a considerable deficit in growth of midface.
- Gilhuus- Moe and Lund demonstrated that after fracture of condyle in a child there was an excellent chance that it would regenerate to app. Its original size

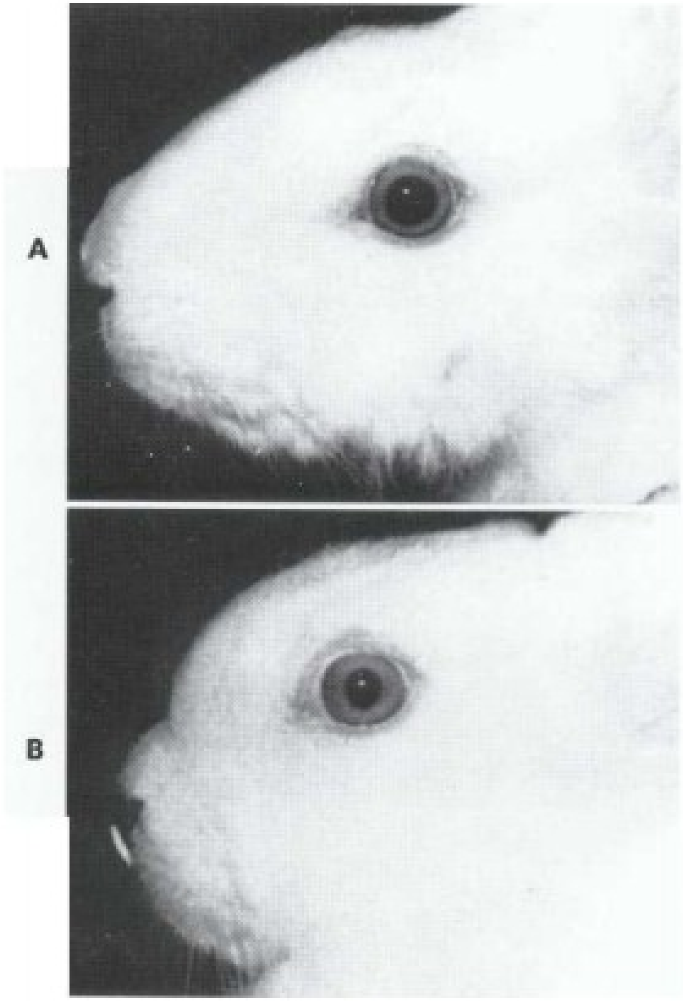


FIGURE 2-35 The effect of removing the cartilaginous nasal septum on forward growth of the snout in the rabbit. A, Normal control. B, Litter mate in whom the cartilaginous nasal septum was removed soon after birth. The deficient forward growth of the nasomaxillary complex after this surgery is apparent. (From Sarnat BG. In McNamara JA Jr. (editor): *Factors affecting the growth of the midface,* Ann Arbor, Mich., 1976, University of Michigan Center for Human Growth and Development.)

FIGURE 2-36 Profile view of a man whose cartilaginous nasal septum was removed at age 8, after an injury. The obvious midface deficiency developed after the septum was removed.

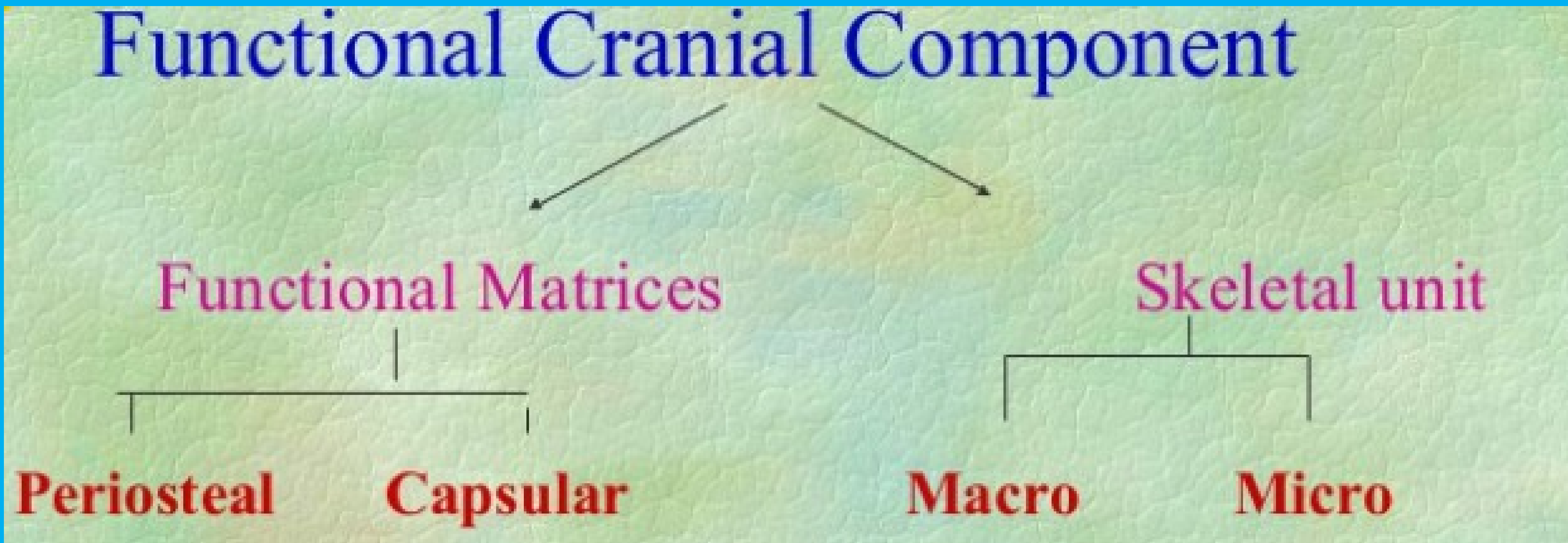
Shortcomings of Scott's Theory

- Transplantation experiments have revealed that condyle has no innate growth potential.
- It is a growth site and not a growth center
- Influenced by local factors
- growth at condyle is entirely reactive

FUNCTIONAL MATRIX HYPOTHESIS (Melvin Moss)

- In this conceptual view, the soft tissues grow, and both bone and cartilage react.
- The growth of the cranium illustrates this view of skeletal growth very well. There can be little question that the growth of the cranial vault is a direct response to the growth of the brain. Pressure exerted by the growing brain separates the cranial bones at the sutures, and new bone passively fills in at these sites so that the brain case fits the brain.

- Another excellent example is the relationship between the size of the eye and the size of the orbit. An enlarged eye or small eye will cause a corresponding change in the size of the orbital cavity. In this instance, the eye is the functional matrix.


Functional Cranial Component
Functional Matrices
Skeletal unit
Periosteal
Capsular
Macro
Micro

- FUNCTIONAL MATRIX : all soft tissues and spaces that perform a given function
- SKELETAL UNIT: bony structures that support the functional matrix and are necessary for that function

FUNCTIONAL MATRICES

1- **Periosteal Matrix**

Relates the matrix to those tissues that influence the bone directly through the periosteum Muscles Blood vessels and nerves lying in grooves or entering or exiting through foramina Affects a microskeletal unit, the influence is usually limited to a part of one bone. All responses of skeletal units to periosteal matrices brought about by complementary and inter related processes of osseous depositon and resorption .They act by bringing transformation of the related skeletal units

e.g. Temporalis – coronoid process

Tooth - alveolar bone

2- **Capsular Matrix**

- Included in this matrix are those masses and spaces that are surrounded by capsules. Neural mass with scalp and dura. Orbital mass with supporting tissues of the eyes. Capsules tend to influence macroskeletal units which means portions of several bones are simultaneously affected Inner surface of calvarium. This sharing of reaction by several adjacent bones constitutes a macroskeletal unit.

- Expansion of the brain i.e closed capsular matrix volume is primary event in expansion of the capsule. The volumetric increase causes compensatory expansion of surrounding capsule which is brought about by mitotic activity.
- Later the calvarial functional cranial component as a whole are passively and secondarily translated .Such translations occur without necessity of involving the processes of selective periosteal apposition and resorption

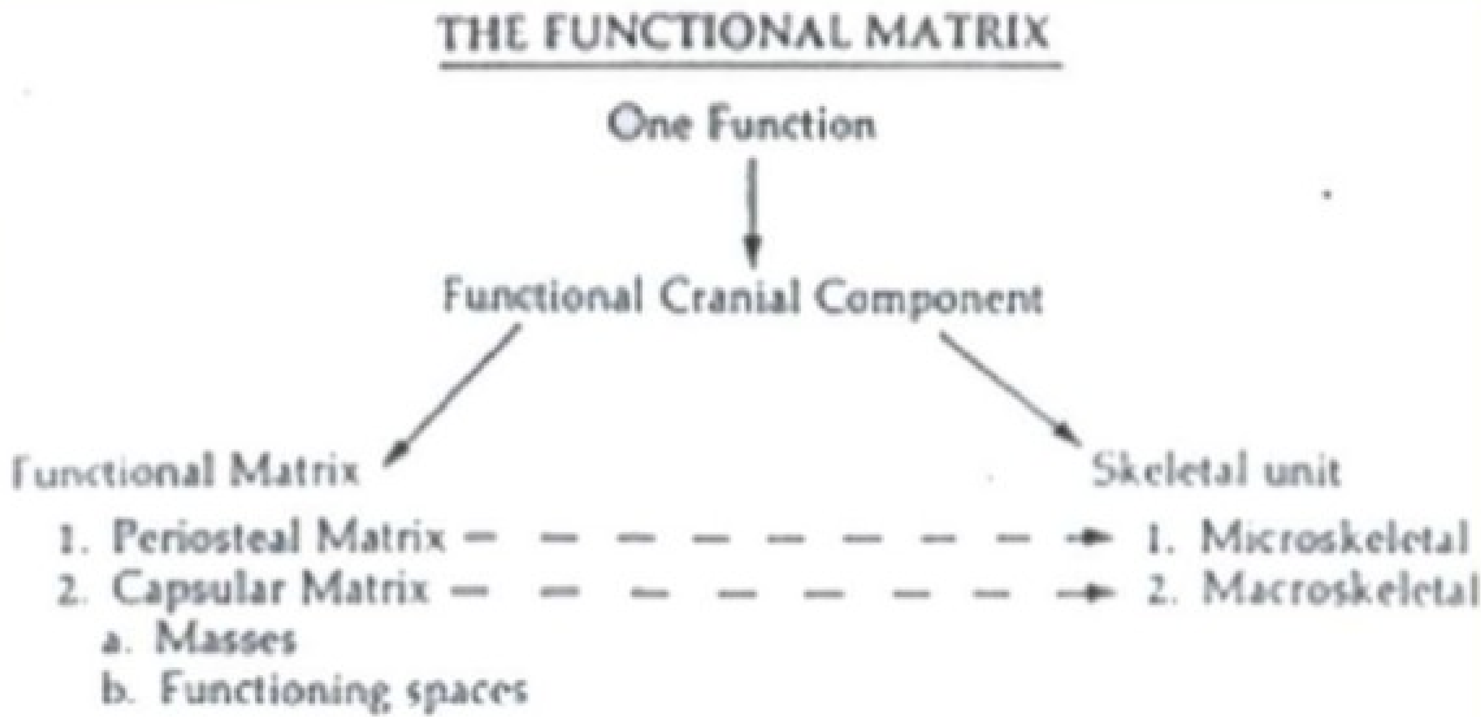


FIGURE 6.3 Classification of the functional matrix.

- Moss theorizes that the major determinant of growth of the maxilla and mandible is the enlargement of the nasal and oral cavities, which grow in response to functional needs. The theory does not make it clear how functional needs are transmitted to the tissues around the mouth and nose, but it does predict that the cartilages of the nasal septum and mandibular condyles are not important determinants of growth and that their loss would have little effect on growth if proper function could be obtained. From the view of this theory, however, absence of normal function would have wide-ranging effects.

- We have already noted that in 75% to 80% of human children who suffer a condylar fracture, the resulting loss of the condyle does not impede mandibular growth. The condyle regenerates very nicely. What about the 20% to 25% of children in whom a growth deficit occurs after condylar fracture?19 Could some interference with function be the reason for the growth deficiency?

Mechanism Of Bone Growth

Mechanisms Of Bone Growth are:

- Remodeling
- Cortical drift
- Displacement

REMODELING

- BONE DEPOSITION & RESORPTION:
- Bone changes in shape & size by two basic mechanisms,bone deposition & bone resorption. The bone deposition & resorption together is called “ BONE REMODELING”.The changes that bone deposition & resorption can produce are:
- Change in size
- Change in shape
- Change in proportion
- Change in relationship of the bone with adjacent structures.

Cortical Drift

- Most bones grow by interplay of bone deposition & resorption .A combination of bone deposition & resorption resulting in a growth movement towards the deposition surface is called “Cortical Drift”.
- If bone deposition & resorption on either side of a bone are equal, the thickness of the bone remains constant.
- If in case more bone is deposited on one side & less bone resorbed on the opposite side The thickness of the bone increases.

Displacement

- Displacement: Growth which causes the mass of a bone to be moved relative to its neighbours. Displacement can be of two types.
- Primary displacement: If a bone gets displaced as a result of its own growth, it is called “Primary displacement”. e.g.. Growth of the maxilla at the tuberosity region results in pushing of the maxilla against the cranial base in a forward & downward direction.

Displacement

- Secondary displacement: If the bone gets displaced as a result of growth &enlargement of an adjacent bone, it is called “Secondary displacement.”e.g.. The growth of the cranial base causes the forward &downward displacement of the maxilla

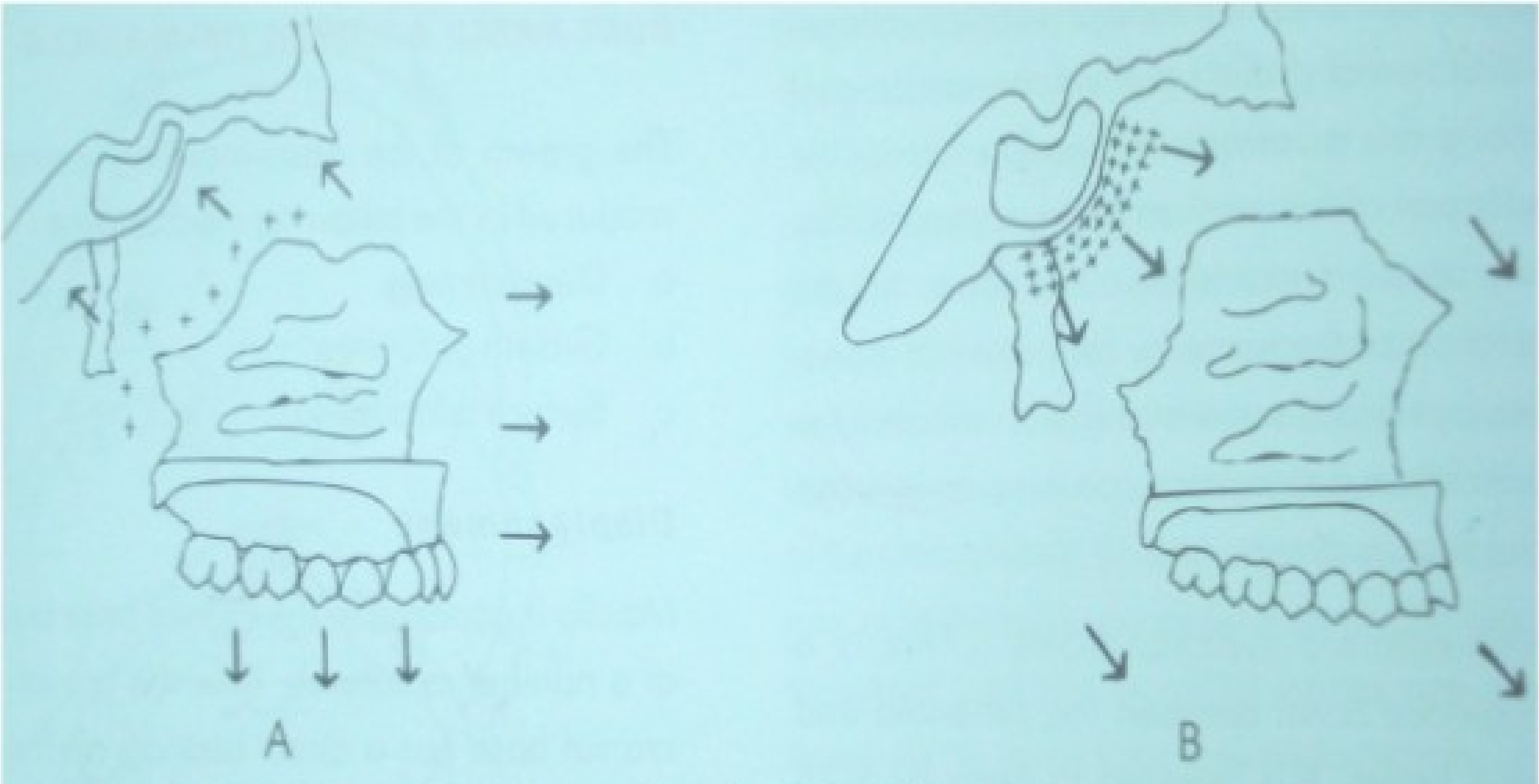


Fig 9 (A) Primary displacement of maxilla (B) Secondary displacement of maxilla

own enlargement

not directly related

Characteristics of Bone Growth

- Bone formation occurs by 2 methods of differentiation of mesenchymal tissues. Accordingly 2 types of bone growth is normally seen.
- 1) Intra-membranous ossification : The transformation of mesenchymal connective tissue usually in membranous sheets, into osseous tissues. E.g. Cranial vault, face (Mx & body of Md) and the clavicles

2. Endochondral ossification: The conversion of hyaline cartilage into bone. E.g. Cranial base, condyle and Epiphyseal plate Proliferating cartilage.

Growth Spurts

- Growth doesn't take place uniformly at all times. There seem periods when a sudden acceleration of growth occurs. This sudden increase in growth is called growth spurt.
- The physiologic alteration in hormonal screation is believed to be the cause for such accentuated growth. The timing of growth spurt differs in boys and girls.

- The following are the timings of growth spurt

a. Just before the birth
b. 1 year after the birth
c. Mixed dentition growth spurt
   Boys 8- 11
   Girls 7-9
d. Pubertal growth spurt
   Boys 14-16
   Girls 11-13

- Growth modification by the means of functional and orthodontic appliances elicit better response during growth spurt . surgical corrections of maxilla and mandible should be carried out only after cessation of growth spurt

Clinical Significance of the Growth Spurts

To differentiate whether growth changes are normal or abnormal.

Treatment of skeletal discrepancies (e.g. Class II) is more advantageous if carried out in the mixed dentition period, especially during the growth spurt.

Pubertal growth spurt offers the best time for majority of cases in terms of predictability, treatment direction, management and treatment time.

Orthognathic surgery should be carried out after growth ceases.

Arch expansion is carried out during the maximum growth period.

Growth patterns

- In studies of growth and development, the concept of pattern is an important one.Pattern in growth also represents proportionality, but in a still more complex way, because it refers not just to a set of proportional relationships at a point in time, but to the change in these proportional relationships over time. In other words, the physical arrangement of the body at any one time is a pattern of spatially proportioned parts. But there is a higher level pattern, the pattern of growth, which refers to the changes in these spatial proportions over time.

- In fetal life, at about the third month of intrauterine development, the head takes up almost 50% of the total body length. At this stage, the cranium is large relative to the face and represents more than half the total head. In contrast, the limbs are still rudimentary and the trunk is underdeveloped. By the time of birth, the trunk and limbs have grown faster than the head and face, so that the proportion of the entire body devoted to the head has decreased to about 30%. The overall pattern of growth thereafter follows this course, with a progressive reduction of the relative size of the head to about 12 % of the adult.

- At birth the legs represent about one third of the total body length, while in the adult they represent about half. As Figure 2-1illustrates, there is more growth of the lower limbs than the upper limbs during postnatal life. All of these changes, which are a part of the normal growth pattern, reflect the "cephalocaudal gradient of growth." This simply means that there is an axis of increased growth extending from the head toward the feet.

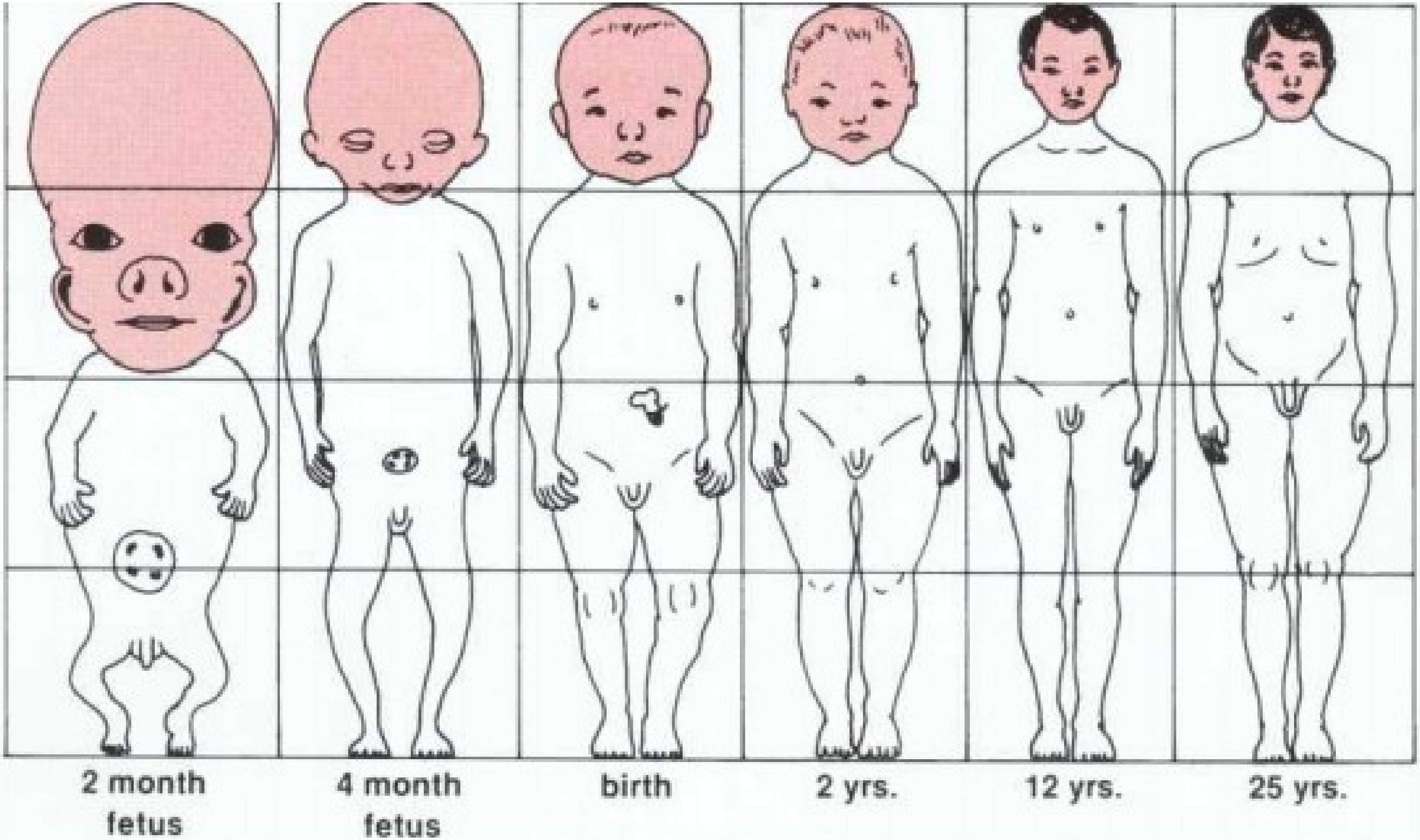


FIGURE 2-1 Schematic representation of the changes in overall body proportions during normal growth and development. After the third month of fetal life, the proportion of total body size contributed by the head and face steadily declines. (Redrawn from Robbins WJ et al: *Growth,* New Haven, 1928, Yale University Press.)

- Even within the head and face, the cephalocaudal growth gradient strongly affects proportions and leads to changes in proportion with growth (Figure 2-3). When the skull of a newborn infant is compared proportionally with that of an adult, it is easy to see that the infant has a relatively much larger cranium and a much smaller face. This change in proportionality, with an emphasis on growth of the face relative to the cranium, is an important aspect of the pattern of facial growth. When the facial growth pattern is viewed against the perspective of the cephalocaudal gradient, it is not surprising that the mandible, being further away from the brain, tends to grow more and later than the maxilla, which is closer.

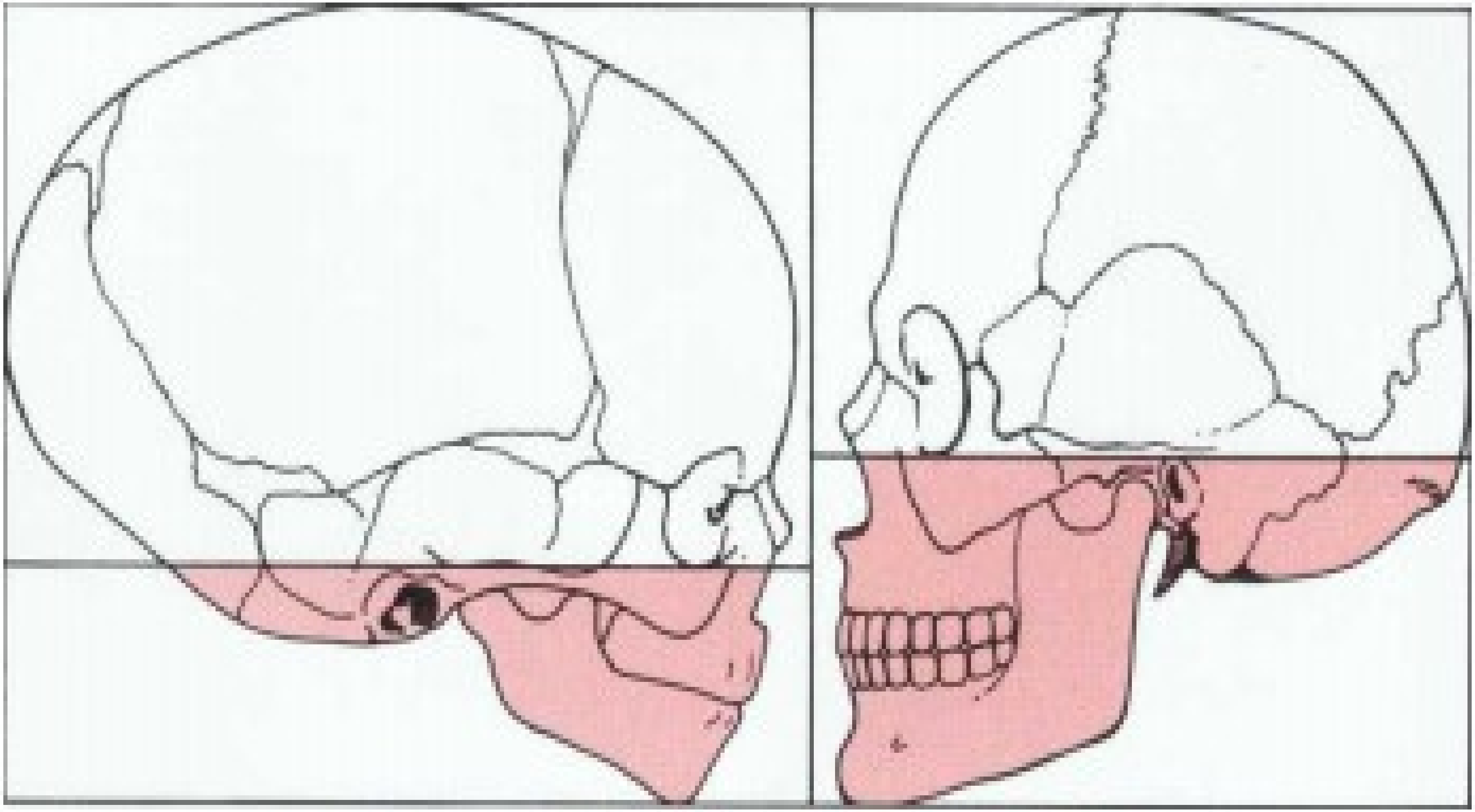


FIGURE 2-3 Changes in proportions of the head and face during growth. At birth, the face and jaws are relatively underdeveloped compared with their extent in the adult. As a result, there is much more growth of facial than cranial structures postnatally. (Redrawn from Lowery GH: *Growth and development of children,* ed 6, Chicago, 1973, Mosby.)

Growth patterns

- Different tissues have different growth patterns (curves) in terms of rate and timing, and four main types are recognized: neural, somatic, genital, and lymphoid. The first two are the most relevant in terms of craniofacial growth.

Neural grow

- this essentially that which is determined by growth of the brain, with the calvarium following this pattern. There is rapid growth in the early years of life, but this slows until by about the age of 7 years growth is almost complete. The orbits also follow a neural growth pattern.

Somatic growth

- Is that which is followed by most structures. It is seen in the long bones, amongst others, and is the pattern followed by increase in body height. Growth is fairly rapid in the early years, but slows in the prepubertal period. The pubertal growth spurt is a time of very rapid growth, which is followed by further slower growth.

- Traditionally, the pubertal growth spurt has been reported to occur on average at 12 years in girls, but there is evidence that the age of puberty is decreasing in girls. In boys the age of puberty is later at about 14 years.

- The maxilla and mandible follow a pattern of growth that is intermediate between neural and somatic growth, with the mandible following the somatic growth curve more closely than the maxilla, which has a more neural growth pattern

- Thus different parts of the skull follow different growth patterns, with much of the growth of the face occurring later than the growth of the cranial vault. As a result the proportions of the face to the cranium change during growth, and the face of the child represents a much smaller proportion of the skull than the face of the adult.