International Journal of Orofacial Myology and Myofunctional Therapy
Official Journal of the International Association of Orofacial Myology

50th ANNIVERSARY

Volume 5 | Number 4 | pp. 7-10 1979

Tutorial

Facial Growth and Development

Donald H. Enlow

Suggested Citation
Enlow, D. H. (1979). Facial Growth and Development. *International Journal of Oral Myology, 5(4)*, 7-10.
DOI: https://doi.org/10.52010/ijom.1979.5.4.3

The International Journal of ORAL MYOLOGY
Volume 5, Number 4   October, 1979

Facial Growth and Development

Donald H. Enlow, Ph.D.
Chairman, Department of Orthodontics
Assistant Dean for Graduate Studies & Research
School of Dentistry
Case Western Reserve University
Cleveland, Ohio

The following paper was presented by the author at a symposium titled "The Application of Myofunctional Therapy in Dentistry and Speech Pathology" and held at Meharry Medical Center, Nashville, Tennessee, April 14-16, 1978. The symposium was funded by the Department of Health, Education, and Welfare.

(Editor)

My purpose is to review with you the basics of craniofacial growth and development. Facial growth is a fundamental and very important subject in fields such as orthodontics, pedodontics, and oral surgery. This will be an overview of fundamentals with emphasis on general principles and basic concepts.

Because growth is a maturational process, two terms are often used in combination: growth *and* development. Together they provide continuous, on-going, differential changes working toward a functional state of morphologic homeostasis.

Everybody has his or her own unique kind of face, a truly one-of-a-kind face. There is great variation in a craniofacial construction. Facial variation is a product of "growth and development," and understanding how, why, when, and what happens during the process of growth is quite important. Rather than making our understanding of faces more difficult, this knowledge greatly clarifies it. First, let me introduce the subject by explaining the basis for different basic kinds of faces. There are great-looking faces and, of course, there are those of us who have less than great faces; long noses, retruded chins, a protruding maxilla, narrow-set eyes, and so forth. There are presently only about three commonly used systems for taxonomically categorizing different kinds of faces and heads. One of these is the type of *headform*. There are those who have a long, narrow headform, a narrow brain, a narrow cranial base, and a long, narrow face; this is the dolichocephalic type of headform. In the brachycephalic type, the brain and cranial base are comparatively broad, and there is a correspondingly wider face.

Associated with headform are certain characteristic features built into the plan of facial structure and, importantly, which underlie tendencies toward the different kinds of malocclusions. There is no such thing as a truly "perfect" facial composite, i.e., a face with precise anatomic "balance" among all of its component parts. In all of us there exist built-in anatomic imbalances. These for the most part are "normal" imbalances, although sometimes the imbalances can be so severe as to constitute an abnormality (e.g., a full-blown malocclusion or one of the various craniofacial dysplasias or syndromes). Virtually every member of the entire world's population is somewhere in a spectrum from one extreme to another with regard to various combinations of normal (and sometimes abnormal) imbalances. Built into the structure of each person's face are Class II and/or Class III "tendencies." You and I and everyone else has a programmed predisposition in either a Class II direction or a Class III direction, or some composite combination in between.

There exists an association between (1) headform (dolichocephaly and brachycephaly), (2) profile type, and (3) malocclusion type. These catagories are interrelated anatomically. The profile types are (1) orthognathic; (2) the retrognathic type, which most of us have; and (3) prognathic. It is easy to eyeball a person's profile type. Visualize a horizontal line coming straight out of the center of the orbit . . . a neutral orbital axis. Then visualize a vertical line perpendicular to this running down along the surface of the upper lip. Then note where the tip of the chin is located in relation to the vertical line. The orthognathic profile in which the chin tip just touches this line, is the "great" face, the classic Hollywood type. However, most of us in the real world have a greater or lesser degree of mandibular retrusion. This is the retrognathic profile in which the chin tip lies somewhere behind the vertical line. A protrusive chin identifies the prognathic type of profile.

A series of facial rotations has taken place during human evolution that relate to brain expansion and bipedal posture. Because of these rotations, together with great variations that exist in headform, the human face has certain built-in malocclusion tendencies. There are, however, *compensatory*, adjustive mechanisms that are operative during the process of craniofacial growth and development. These growth adjustments usually (not always) reduce potential malocclusions to a "normal" (Class I) level.

Those of us who have the narrow facial form, a narrow brain and a narrow cranial base tend to have a characteristic composite of facial features. The same is true for the wide headform type, but the facial characteristics are quite different. A narrow face has a correspondingly more narrow "set" to the eyes; the eyes tend to be closer together because the whole face is more narrow, in comparison to the more wide-set eyes of the brachycephalic face. In a dolichocephalic head, the nose is also more narrow because the whole interorbital nasal compartment has a more narrow dimension. The nose is thin, but it is also more protrusive. The wider nose of the brachycephalic face tends to be shorter and much less protrusive. It is thereby equivalent in airway capacity to the narrow but longer and more protrusive nose (and nasal chamber). Because the nose tends toward more protrusiveness in the narrow-type face, the whole upper [illegible] of the face and forehead also tend toward greater protrusiveness, in comparison to the wide-type face. The outer table of the frontal bone develops protrusively with the nose, the frontal sinus is enlarged, and a much greater extent of supraorbital ridge overhang thereby occurs. The more sloping forehead exists in comparison to the brachycephalic face. The latter has a smaller frontal sinus, a lower nasal

Int. J. Oral Myol.
October, 1979

bridge, a straighter nose, and a more upright forehead. Because the upper part of the nasal region tends toward greater protrusiveness in the dolichocephalic face, a bending of the nasal profile often occurs, i.e., the Roman, the Dick Tracy, or the aquiline type of nose. In the long, narrow headform there is a different configuration of the cranial base; it tends to be somewhat more open (i.e., flat), and this also contributes to nasomaxillary protrusion as well as mandibular retrusion.

Related to all of these features is a tendency for a retrognathic facial profile in narrow-faced individuals along with a tendency toward a Class II malocclusion. In contrast, a greater tendency toward an orthognathic profile, a somewhat more prominent mandible and a flatter, wider facial configuration characterizes wide-faced individuals. In any population, there is a wide range of variation between the extremes, but there tends to be a predominance one way or the other. In some (not all) persons of European descent, for example, a predominance of dolichocephaly with the long headform, narrow face, a more protrusive nose, and a retrusive mandible exists. In the Oriental population (mostly brachycephalic) there is a tendency toward the wide-faced configuration with, thereby, wider-set eyes, a more bulbous forehead, a shorter nose, and a somewhat more protrusive mandible. However, in the Oriental population, variation in headform is such that there are also some narrow-faced individuals with more "Caucasian" characteristics because their headform is more narrow, the face is correspondingly more narrow, the eyes appear more close-set, the nose is thinner and the mandible tends toward retrusiveness giving a convex, retrognathic type of profile. The latter is a less frequently encountered facial pattern, however, among Oriental individuals. In a Japanese orthodontic practice there are far more Class III and bimaxillary protrusion patients encountered, and far fewer Class II's. In a typical American orthodontic practice there are many more Class II's and fewer Class III's, for the reasons just explained.

Differences between male and female faces are also evident. These are based largely on differences in the breathing part of the face, that is, the ethmomaxillary component. The female tends to have a somewhat smaller body, overall, smaller muscles and bones, and a smaller airway leading to the smaller lungs. The characteristic features of the female versus male face relate directly to these differences. The guy with the big lungs has a big nose to provide for them. The nose is longer, sticks our further, and it's noticeably wider. The protrusiveness of the upper part of the nose causes a greater tendency toward the aquiline configuration, in contrast to the female in which the nose is thinner, less protrusive and tends toward a concave-to-straight nasal profile, especially among wider-faced females. The male nose tends toward a straight-to-convex profile, especially among more narrow-faced individuals. The male with the bigger nose has a bigger frontal sinus because the outer table of the forehead is carried farther forward with the more protrusive nasal region, and the forehead is therefore more protrusive. Note these other distinguishing male-female facial characteristics. The extent of supra-orbital protrusion is much more marked and distinctive in the male. The female forehead is more bulbous and more upright, whereas the male forehead is more sloping. Because the female has a lesser amount of forehead, supra-orbital, and nasal protrusion, the adjacent cheekbone region tends to appear much more prominent. "High cheekbones" are a traditional mark of classic female beauty. The cheekbones of the male often tend to be less noticeable because of the massiveness of his nose and protruding forehead.

There is another nose type that is commonly associated with the male face. This is the classic "Greek" nose. The aquiline or bent nose configuration, as previously explained, is caused by the protrusiveness of the upper part of the nasal region. A variation exists in which the whole nasal profile "rotates" into a much more upright alignment. The profile of the nose thus drops almost straight down from the protruding forehead. Frequently there is also a downward tipping of the point of the nose, in contrast to the short nose (either male or female) which often tips upward.

Part of our job in growth and development is to also understand the morphologic and morphogenic basis for the changes that take place in a given individual at different ages. It's really not all that complicated a story and it's very interesting. First, growth and development is, as I said, a maturational process involving differential enlargement over a period of years. *Remodeling* is involved. Is the skull of a little child merely a miniature of the adult's? Of course not. There are great differences in regional proportions and relationships. The process of growth and development involves a progressive sequence of structural changes as the child grows and develops, year by year, to finally achieve a morphologic maturity and developmental homeostasis. Growth is not simply a process of equalized enlargement by any given bone. This is one of the great presumptions that must be overcome by beginning students. The bones get larger, but it's not merely "growth"; it's growth *and* development. There is much more to growth than merely deposition of more and more bone. The instructors that teach anatomy usually state (quite incorrectly) that a bone grows simply by osteoblastic deposition on the external surfaces of the bone, with osteoclastic resorption from internal surfaces, and that's how it gets bigger. That is just *not* the way it happens. I'll make a quick statement and you'll see the significance later: About half of the outside surface of most bones do not actually receive new bone additions at all. They are in fact undergoing bone *removal*. About half of the bone is *not* produced by the periosteum, it is laid down by the endosteum. How can the bone grow if it's losing bone on half of its outside surface, and if half of that bone is actually produced by the inner, not the outer, membrane? The reasons will become evident as we describe the growth process.

Every bone has a mozaic of "fields" of growth and remodeling. Some of these fields are resorptive, with osteoclasts at work, and some are depository (osteoblasts). This provides for *remodeling*. The bone can't grow unless it undergoes a simultaneous process of restructuring; the *moving* of the component parts and regions of the bone to allow for the whole bone's enlargement. The same cellular activities which produce enlargement also simultaneously produce remodeling.

A bone grows by two separate kinds of growth movements. One is termed "displacement" and will be explained later. The other type involves *remodeling,* that is, different combinations of bone deposition and bone resorption in the different regions of a whole bone. Bone deposition occurs on one side of a given cortical plate as bone resorption takes place simultaneously on the other side. As a result, the cortex undergoes a growth movement. The amount of deposition slightly exceeds the amount of resorption and, thereby, everything becomes larger and thicker. New bone is added on the side pointed toward the growth direction, with resorption from the opposite side.

The two zygomatic arches, for example, grow in such a way that the right arch progressively moves to the right and the left arch moves to the left. How else could the cranial base, the brain and the face be free to expand laterally if the two zygomatic arches did not move out ahead of them? The arches move by the process of remodeling. They occupy successive new positions as the whole face becomes wider. Bone is deposited by the periosteum on the lateral side of each arch and resorbed by the periosteum on the medial side. The cortical bone on the medial side is laid down by the endosteum.

Why does a bone remodel? It is because the parts of any given bone must undergo *relocation,* as just seen. In the growth of the mandible, for example, the whole ramus moves and relocates posteriorly. It does so by the remodeling process: by deposition of bone on posterior-facing surfaces and resorption from anterior-facing surfaces. Why? The remus relocates posteriorly to allow for the lengthening of the corpus. What used to be ramus becomes structurally converted (remodeled) into an enlarged and lengthened corpus to house more and more teeth and to provide attachments for progressively bigger muscles.

Another example: the palate undergoes a marked descent (inferior relocation) during facial growth. The palate at age 2 or 3 years is not the same actual palate at 9 or 10, 12 or 13 years of age. The palate moves, by remodeling, inferiorly. It does so by removal of old bone on the nasal side and addition of new bone on the oral side. Everything is *moving* and *changing* in a vertical direction, and the palate occupies successive new locations as it becomes composed of new bone enclosed by new connective tissue membranes.

The hard palate in the young child is almost at the same vertical level as the orbital floor. In the adult, the palate has come to lie well inferior to the orbital floor. Each nasal chamber has become progressively enlarged, as a result, as it continues to match the simultaneously increasing size of the lungs. When you were a child, your maxillary arch was located where part of your nasal chamber now is. Your maxilla as a child became "relocated," and what used to be your maxillary arch became structurally converted by the remodeling process into an enlargement of your adult nasal chamber.

Now for that second great category of growth movement called *displacement.* Visualize two rubber balloons held between your thumb and forefinger, with both balloons simultaneously being blown up. The balloons shove each other apart as they enlarge, and the amount they move apart (displacement) is determined by the composite extent of their enlargements. Now, the mandible enlarges upward and backward but, of course, is is in articulation at the temporomandibular joint. How can the mandible grow when in articular junction with another bone? It does so in company with the process of displacement. As the mandible *enlarges and remodels* superiorally and posteriorally, it simultaneously becomes *displaced* anteriorally and inferiorally. The amount of the anterior and inferior displacement almost exactly equals the extent of upward and backward remodeling enlargement. Just as the two balloons undergo positional adjustment to accommodate their respective increases in sizes, so does the mandible. As the mandible enlarges upward and backward, the whole bone moves forward and downward by the same amount.

Here is the big question, one of great importance. Do the balloons (1) push each other apart *because* they enlarge, or (2) are the balloons first separated and *then* enlarged by the amount of the separation? This is an active argument going on among researchers today.

Many investigators hold that the whole mandible is not being pushed or shoved downward and forward as a *result* of its own growth upward and backward. Rather, the whole mandible is *carried* forward and downward by the growth expansion of the musculature, the mucosa, the tongue, and all the other soft tissues of the face. This growth process of the soft tissue and the resulting anterior and inferior displacement of the whole mandible creates the spaces into which the mandible then secondarily but virtually simultaneously grows and enlarges.

The condyle is always emphasized in the literature as *the* important growth site of the mandible. However, this is not the location where the whole growth process is now believed to be actually regulated. It is not controlled by genetic programming within the condyle itself. The condyle does, however, provide a means for the enlargement of the mandible at its site of articulation. That's why cartilage is there. The condylar cartilage provides an endochondral bone growth mechanism to allow for bone enlargement in a region of surface pressure. The cartilage is not there, however, to provide "pace-making" control for the whole of mandibular growth. The latter is an old idea that now is regarded as obsolete by many investigators. The control of mandibular growth, rather, is believed to involve all of the muscles, the connective tissues, and the neural relationships associated with the mandible for feed-back from sensory receptors located in the periodontal membrane and throughout the oral and facial regions. It's an extensive regulatory process that is far beyond mere condylar control. The new idea that is now replacing the old condylar growth "center" concept is really far more significant than that of the condyle merely serving as a pacemaker. What occurs during growth is a provision for the progressive enlargement of the mandible, the maxilla and the basicranium in *relation* to one another. The mandible must continually adapt to the others so that it can come into a junctional relationship with the cranial base on one side and the nasomaxillary complex on the other side. It is this *adaptive* capacity of the condyle (and the whole ramus) that is so important, and this is believed to represent the key role of the condylar growth mechanism. There are relatively few really severe malocclusions because of it. If the condyle were to function strictly as a pacemaker with built-in, unchangeable, pre-programmed control, the overall mandibular and craniofacial growth process would be unworkable because the mandible couldn't adapt to the wide range of anatomic and developmental variations existing throughout the other parts of the skull. It would not be able to progressively modify its amounts and directions of growth to provide a functional occlusion.

The nasomaxillary complex is also carried forward and downward by the displacement process, presumably also as the result of the expansion of the facial soft tissues. Displacement has a separating effect at all of the various maxillary sutures. As the nasomaxillary complex becomes displaced forward and downward, sutural bone growth then takes place, thereby filling the "spaces" that would have been created. All this is simultaneous. No real space ever develops because bone growth is triggered by the osteogenic membrane of each suture as the maxilla is being displaced. Immediate bone deposition at the suture thereby maintains constant articulation without any real space developing. The amount of bone growth is determined by the amount of displacement. If the whole maxilla is displaced, say, 5 mm. forward and downward, there will then occur 5 mm. of sutural bone deposition in response to the displacement. The process of displacement, in effect, is creating the on-going "spaces" into which the maxilla enlarges. The maxila and the mandible both enlarge posteriorly, as just explained, as they simultaneously become displaced anteriorly. The cheekbone also enlarges posteriorly at the same time. You probably didn't realize that the anterior surface of your malar protuberance was resorptive during the growth period. It underwent osteoclastic removal, not bone deposition, because as the maxillary arch grows backward, the cheekbone must remodel backward with it to maintain constant position. The posterior side of the cheekbone is depository.

These various growth changes progressively alter the shape and topographic contours of the whole face as one gradually develops to skeletal maturity. The nose remodels forward in order to enlarge the nasal chamber to keep pace with increasing lung size. The forehead remodels forward along with the subadjacent nasal region. The cheekbones, however, remodel posteriorly to keep pace with the backward-lengthening maxillary arch. Then *everything* is displaced forward. If one runs a line along the upper and lower margins of the orbit on a profile view of a little baby, and then the same person as an adult, one will note that the facial profile undergoes a marked rotation as a result of continued upward facial protrusive and lower facial retrusive remodeling. The face becomes deeper, less flat, and topographically much more irregular, bold, and prominent. In the female these various facial growth changes continue until about 13 or 14 years of age. Then they essentially cease. During male facial growth, however, remodeling changes continue for several more years. This brings about the characteristic sexual dimorphism in facial structure and appearance.

In summary, if you're going to attempt to clinically affect growth, if you intend to intercede and actually try to alter and manipulate the growth process, then you *must* know exactly what the detailed growth events are and have an in-depth understanding of the growth process itself. What I've just been through with you is a bare introduction. This, and much more, is essential information for you. And that is my message.