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The Life History of the Normal Denture*

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The life history of the human denture is in its very nature so closely related to and so interwoven with the problems of growth and development that the terms are almost synonymous. It is a story not alone of the area comprising the jaws and dental arches but must of necessity include the whole of the face and the cranium and must cover the period of time from the beginning of foetal life through childhood, adult life and the decline which comes with senility. The purpose of this paper is not to promulgate any views or opinions of our own but rather to review the experimental work of past investigators in the field with special reference to that of a more contemporaneous nature.

Normal occlusion as it appears in man has not been acquired in a few years, nor can the life history of the denture be considered without due regard to past development of the denture through the various geological eras. Two urges have been present from the very beginning in all creatures of the animal kingdom: the urge to eat and the urge to reproduce their kind. Even before any other features were developed as part of the face there was present an opening which became the mouth. This has changed and developed until a highly specialized organ of mastication is the result.

According to Gregory[1] our present face with its particular plan of mastication has been reached through a process of simplification. The skull form

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in the early mammals presented elongated heads and prominent muzzles. In the anthropoid group there is a decided change with noticeable shortening of the jaws and an increase in vertical height. A number of the facial bones which were more numerous have been included in what is now the maxilla and the mandible. Somewhere between the mammalian-like reptiles and lower mammals a one piece jaw replaced a jaw made up of many bones. The dentary bones as they increased in size crowded out the elements behind them, joining in the region of the symphysis to make a single bone.

The muscles underwent accompanying changes. What originally had been a protective armor in early vertebrates divided and split up when the bony framework became fenestrated and in its dividing grouped itself into muscle masses which later became the facial muscles or muscles of expression. The muscles of mastication, which in early vertebrates were masses of muscles arranged to bring about a simple closure of the jaws, also divided at first into the temporal and masseter muscles and later the pterygoids. The pressure of the dentary bone against a muscle mass is believed to have caused the development of a cushion which later became the articular disk. The continued pressure of the dentary bone against the opposite bone made a depression which anticipated formation of the temporomandibular articulation, thus making possible lateral and protrusive function.

Even the attachment of teeth went through various stages. Fibrous attachment, elastic hinge attachment, and attachment by ankylosis preceded that of implantation in a socket, with its intervening fibrous membrane between bone and tooth.

Tooth form developed from the time when the dermal scales revolved, as it were, into the mouth cavity and became rudimentary teeth, on up through the periods when teeth had either no roots or else single roots, and crowns were largely conical in form. These tooth forms existed only during those periods when the jaw function was uncomplicated, presenting a simple hinge action. Somewhere along the line of development the tooth form changed from the cone shaped tooth to the triconodont and from this to the tritubercular tooth with its many variations. This probably occurred after the formation of the temporomandibular articulation, tooth form following closely upon the heels of function. We find in present day mammals that a definite relationship has been established between the arrangement of the teeth and their function. The relationship of cusps which has been maintained over these long periods of time can not be disregarded when the modern human denture is considered.

The true carnivors illustrate well this relationship of tooth form and function. The only action possible for the mandible to perform is a simple hinge action. Due to the construction of the condyle and fossa no lateral or anteroposterior action is possible. The cuspids, which are large, serve as guides when the mandible closes so that the cusps of the posterior teeth slide over each other always in the same way. This gives a perfect shearing action. The rodents, most of which have an anteroposterior action with perhaps some slight lateral motion, have the cusps arranged transversely to the direction of movement of the jaw. These transverse ridges or blades are so related in the upper and lower arches that when they pass over each other they produce a shearing action similar to that in the carnivors. Most of the Ungulata, especially the true herbivorous animals, in their lateral excursions of the jaws also produce a shearing action whether they are the flat teeth of the horse or the triangular and crescentic ridged teeth of the cows, sheep, and deer.

Dewey Thompson[2] states that in considering the growth and development of the denture we must remember that the teeth and jaws of man closely resemble those of the apes below him, both in form and structure. The teeth of man might be considered somewhat degraded in form and structure when compared with the highly specialized forms to be found in some of the other animals. From the higher apes to lower man the gap is not so great, as it is between the higher and lower races of man.

In man there is a tendency to reduce the size of various parts of the denture. This gradual lessening of function has led to a degradation of the denture, all in accordance with the laws of economy of growth of unused parts. Therefore we have the fourth molars entirely missing except in the case of some of the native Australians. The teeth thmselves, together with all their supporting structures, are reduced in size generally; the molars decrease in size from the first molar to the third, which is often rudimentary or missing entirely. The upper lateral incisor too, is often stunted or missing and seems to be following those teeth of man which have passed. Our best dentitions are those that have animal perfection in form and organization.

We can easily see the direction in which the denture of civilized man is tending, if we but examine the dentures of the earlier races of man with their large, well formed teeth and massive prognathous jaws and then turn our attention to the evidence of their diminution as the later civilizations are approached.

The teeth of man should present just as definite relationships when normal as do the teeth of other mammals, whether we consider the denture at the age of three, five, eighteen, thirty or ninety. That is, there is a definite cuspal relationship for every stage of the development of the denture as well as a definite relationship of the denture to the skull. The mistake of keeping in mind the general concept of normal occlusion for the adult has too often been made when considering the denture of the child at its various stages of development.

Todd[3] has referred to growth as involving three concepts, namely "increase in dimension, change in proportion, and adjustment of parts," and further that "The most important aspect of growth is not size or dimension—it is that aspect which we usually call development, that is to say modification of proportions with increasing maturity."

Obviously where there is such a variation in the comparative amount of growth and development in different individuals of the same age it is not possible to use the chronological age as a measure of comparison. We have therefore for the purpose of this paper divided the developmental progress of the individual into three stages:

1. The formation and completion of the deciduous denture.
2. The period beginning with the decline of the deciduous denture and ending with the completion of the permanent denture—early adulthood.
3. The permanent denture—its rise and decline.

The Deciduous Denture

With reference to the embryonic development of the jaws, Franklin P. Mall[4] gives the following report:

> "The mandible appears a very little later than the clavicle—in embryos 15 mm. long, 39 days old, it is present as a finely granular or reticular mass half a millimeter long, immediately below the epidermis—representing of course the body of the jaw. On the 42nd day the bone measures 2 mm. and shows the beginning of the ramus and of the alveolar process. At 55 days it is 5 mm. long and shows the beginning of the coronoid process and the condyle—At 57 days a few sockets for the teeth may be seen in the alveolar process—By the 75th day the jaw has grown to be 10 mm. long and meets its fellow to form the symphysis on the mid ventral line—about this time the mylohoid line and the lingula appear. On the 83rd day the ramus is becoming relatively thinner and broader, the coronoid process has moved further away from the condyle, the angle has become more marked and the alveolar process has increased in length. The mandible has now its characteristic shape and measures 14 mm. in length.
>
> "The maxilla arises from two centers only, one to form the premaxillary bone and one to form the main body. The maxilla is just beneath the eye over 1 mm. in diameter and the premaxillary is small and separated by 1 mm. from the maxilla—These two bones are found united along the alveolar border on the 56th day—after the premaxillary bone joins the maxilla it is in general cubical in shape measuring on a side 3 mm. on the 65th day—4½ mm. on the 75th day and 6 mm. on the 85th day. At this time and in older embryos its form is characteristic."

The temporary teeth begin to form about the seventh week of foetal life and continue growing until the age of three years. The permanent teeth begin to form at the seventeenth week of foetal life just as the deciduous teeth begin to calcify and their calcification begins just before birth. When one considers the tremendous number of biological and physiological changes taking place within the developing maxilla and mandible during this early period one understands how development, or an increase in complexity, far exceeds the growth process, or increase in size.

Friel[5] noticed that immediately after birth the maxillary arch was directly above the mandible, but attributed the distal appearance of the lower jaw to the prominence of the upper lip. However, the observations of Wilkensen, Hellman, and many others indicate that there is a decided distal relationship of the lower arch to the upper at birth. Campion and Millard[6] have demonstrated that "at birth there is such a preponderance in development of the cranium over the face that a line drawn from the centers of ossification of the frontal bone downwards through the nasion would pass through or behind the base of the nose and through the body of the mandible about one third of the distance from the symphysis to the angle." The position of the foetus in utero with head bent forward and chin resting on the thorax undoubtedly has its effect on the lower jaw and makes the latter observations seem correct. Thus at birth the normal relationship of the dental arches seem to be for the lower arch to be distal to the upper.

Brash[7] shows a comparison of a normally developed adult male skull in comparison with that of a skull at birth. The two skulls are oriented on the Frankfort plane and clearly demonstrate the growth changes that take place from birth to adult life. From this comparison we can readily note that the greatest proportionate growth in the head is in the region below the Frankfort plane or that occupied primarily by the maxilla and the mandible, and later on he presents the following conclusion: "The forward growth of the maxilla is essentially due to increase of its body in both directions associated with its simultaneous excavation by the expanding antrum and a downward and forward growth of the alveolar border carrying the teeth."

After birth for a few months there is a forward growth of both arches but relatively more growth in the lower than the upper. After the completion of the deciduous dentition there is considerable growth in an anteroposterior direction and some vertical growth in the maxilla and the mandible but the vertical growth in these bones is greater after the eruption of the first permanent molars. There is also a certain amount of lateral growth which must be obtained in order to properly accommodate the permanent teeth.

There is considerable variability in the sequence of eruption of the individual teeth of the deciduous denture, but taken in groups the order of eruption is fairly constant. First to erupt are the central incisors, next the lateral incisors, then the first molars followed by the cuspids and lastly the second molars.

When the deciduous denture is complete there normally exists an overbite in the anterior segments of the arches which gradually changes to an edge to edge relation just before the first permanent teeth erupt. This is due to natural wear and by a greater forward and lateral growth of the lower arch. Atkinson has pointed out that at the completion of the deciduous denture the second molar rests under the malar process or key ridge and thereafter moves forward from this position to allow the first permanent molar to take its normal position in the arch.

The deciduous dentition is at its best between the ages of two and one-half to four years; after that time the process of resorption of the roots takes place to make way for the erupting permanent teeth. The cusps begin to show signs of wear after they have functioned for a time and become much flattened and worn, affording no means for guiding the mandible as they did during the period before this abrasion took place.

The Mixed Denture

The absorption of the roots of the deciduous teeth is a question that has puzzled histologists since this phenomenon was first recognized as a physiological process. A hasty review of the mechanical features of this phenomenon with which you are all familiar might be in place. As described by Tomes,[8] "The root, at or near to its end, becomes excavated by shallow cup shaped depressions, these deepen, coalesce, and thus gradually the whole is removed. Although absorption usually commences on that side of the root which is nearest to the successional tooth, it by no means invariably does so; it may be, and often is, attacked on the opposite side and in many places at once. The cementum is usually attacked first, but eventually dentin and even enamel come to be scooped out and removed by an extension of the process. The absorption of the temporary teeth is independent of pressure." Until further work of a histological nature provides us with more definite facts we must accept the statement of Noyes[9] that "it seems strongly evident that osteoclasts or their endothelial predecessors are the active agents of absorption, although the method by which they accomplish it is unknown."

The phenomenon of absorption is immediately followed by that of eruption of the permanent teeth which has been spoken of "not as a local phenomenon but an episode in the growth of the jaws."[10] A complete presentation of the theories concerning this development process are beyond the scope of this paper; however, a brief summarizing of those most generally accepted has a place within its limits. The multiplication of cells of the pulp as described by Noyes in which the pressure exerted by this cell proliferation between the large open root of the tooth and the floor of the alveolus forces the tooth to emerge from the crypt.

Hunter and others who followed him believed that the elongation of the root was responsible for the emergence of the tooth from its crypt. Kollicher described the eruption of teeth as follows: "By the beginning of eruption the crown is formed but the root is still growing. The germ therefore grows in length and is pressed out by dentin formation against the roof of the alveolus."

Demolis,[10] whose investigations have been quite extensive, arrives at the following conclusions: "On the whole, then, dental eruption would appear to be the result of two antagonistic phenomena; growth of the root and proliferation of the socket base assisted by the reduction of the borders of the socket walls."

Kronfeld[11] in discussing the eruption of the first permanent molar states, "that a significant result is that distance between the lowest point of the tooth germ and the mandibular canal remains practically stationary. At fifteen years it is hardly twice as much (2 mm.) as at birth (1 mm.) in comparison to a total height of the tooth from 5 to 21 mm. This is additional proof of the incorrectness of the old conception, "that the forming root grows into the jaw." It shows the correctness of Orban's statement "that Hertwig's sheath is the relatively fixed point in tooth development and that the entire growth of both crown and root takes place in an occlusal direction, out of the jaw." Kronfeld further offers proof of the statement of Burtin, Leist and Priesel, "that the distance between the lowest point of the molars and the mandibular canal does not change to any marked extent, but that this distance remains constant and the entire growth of the tooth takes place occlusally." He sectioned two mandibles, one of three years and one of eight years, through the mesial cusps of the lower first molar. In both cases the relation between the lowest point of the tooth and the center of the canal is the same.

All textbooks in dealing with the question of tooth eruption place unnecessary stress upon the chronological time of eruption, failing to emphasize properly the more important significance to be attached to the sequence of eruption. It has been well stated that "it is a matter of common observation that one child may be accelerated and another retarded as judged by the number of teeth present at a certain age yet both may ultimately develop a normal dentition and it has been observed, however, that when dental retardation is associated with disturbances in the sequence of eruption the incidence of malocclusion becomes extremely high. The cause of this disturbance is not yet entirely clear—it does seem to be evident that a normal sequence in the eruption of the teeth is more important than maintaining a normal time schedule."

Of all the forces acting upon the growth and development of the denture, that caused by the wedging action of the erupting permanent teeth is one of the most powerful, as well as one of the most important to the normal positioning of the teeth in the permanent denture. If the habits of the individual are such as not to cause abnormal pressure against the jaws, this wedging action or eruptive force excited by the incisors and cuspids will cause a lateral and forward growth in the anterior part of the jaws sufficient to contain the six permanent anterior teeth, in their normal positions. It will be noted that in many normal dentures the lower first permanent molars erupt and come into contact with the cusps in a more or less edge to edge relation with their opponents in the maxilla and that upon the loss of the lower deciduous cuspid and molars in which the mesiodistal diameter is greater than that of their permanent successors the first molar moves forward to a normal locking with its antagonist in the maxilla. The following explanation of this phenomenon has been advanced by Dr. Spencer Atkinson: At the growth stage in which the upper and lower first molars normally come into occlusal contact the development of their roots is such that they would be unable to withstand the torsional stress to which they would be subjected were the cusps to lock in normal adult relation. At the time that the lower second deciduous molar is lost the roots of the permanent first molars are fully developed and, now being able to withstand these torsional stresses, the lower molar moves forward to take its place in normal cuspal relation with the upper. In further proof of this he has called attention to the fact that in deciduous dentures which through lack of use suffer little or no wear of the occlusal surfaces these teeth are lost early while in those dentures in which the occlusal surfaces are so worn that there is no lateral stress from the locking of the cusps the teeth are usually retained beyond their normal period.

The changes in the dentition during the period of late childhood and early adolescence are of particular import to orthodontists as it is during this stage that the development of severe malocclusions is most evident. Dr. Samuel J. Lewis,[12] after eight years of observation and measurement of the models of children at the Merrill Palmer Institute, has arrived at the following conclusions:

1. The combined diameters of the deciduous incisors are of little value as an index of the size of the permanent incisors.
2. We cannot predict the alignment of the permanent incisors on the basis of the alignment of the deciduous incisors.
3. The diameter of the deciduous incisors appears to bear some relation to their spacing—those with smaller diameters tend to show the wider spacing.
4. The spacing of the deciduous incisors appears to bear little relation to the alignment of the permanent incisors—there are other growth factors to be considered.
5. The alignment of the permanent teeth cannot be accurately forecast on the basis of the relation between intercanine growth and the difference between the diameter of the deciduous and that of the permanent teeth.
6. The incidence of malocclusion increases as the deciduous denture passes to the mixed stage—malocclusion sometimes changes to normal or borderline normal occlusion—and some types of malocclusion change to another type during the transition period.

These observations of Lewis confirmed the statement of Hellman,[13] that of 1,100 New York school children of those examined at the age of four, 70 per cent had normal occlusion but with the increase in age there was a decrease in the relative frequency of the normal so that at nine the normal in occlusion was 22 per cent—but after this age there is an improvement and the normal rises again so that at fifteen it reaches 40 per cent. He follows with the statement that "The normalcy of the child's dentition can be appraised only in accordance with the stage of development attained at the time it is observed," and further we must remember in all our diagnosis that, "the child's dentition is not a finished product and therefore cannot be measured by standards of the adult."

It is during the important years of the changing denture that we notice the most marked growth changes both in direction as well as in amount. This was shown by Hellman[14] who, in an examination of a number of ancient Indian skulls all from the same locality and of varying ages, found the following facts regarding the growth of the face:

> "The measurements of the faces of these skulls . . . show not only that the face grows in the course of development but also that when it grows it follows certain characteristics inherent to all growth phenomena: *i.e.* its growth varies in intensity at different stages of development—it grows, for instance, more rapidly at first, slows down, and then speeds up again. But while it continues to grow until old age, the rate of growth becomes slower and slower as age advances. The greatest amount of growth takes place during adolescence . . . Referring to the dental development it is quite clear that the first

marked increase in facial height is coincident with the completion of the deciduous dentition; the second and the most significant one, during the completion of the permanent dentition. The first slowing up in growth occurs during the period preceding the loss of the deciduous teeth, and the second, after the completion of the permanent dentition. But while the first retardation is temporary, the second retardation continues until old age sets in, terminating . . . with the loss (and wear) of the permanent teeth."

The direction of bone growth in the maxilla is in three directions—in vertical height, in width, and in depth. The downward growth is due principally to the tremendous amount of alveolar bone which is developed in response to the demands of the erupting teeth. The lateral growth is caused by the deposition of alveolar bone as well as by additions to the palatine suture. Growth in depth is a result of an accretion of bone on the tuberosity as well as to change in inclination of the anterior teeth. In the mandible, according to Brash[7] seventy percent of the vertical growth is due to the addition of alveolar bone and thirty percent to addition of bone to the lower margin of the body. Growth in width is a result of lateral growth at the base of the skull which forces the condyles apart in addition to deposition over the anterior surface and absorption over the lingual wall while growth in length is due to deposition of bone upon the distal surfaces of the angle and the ramus.

It was observed by Hunter that the jaws lengthen only at their posterior ends; that the first permanent molars which were under the coronoid process in the lower jaw and in the tuberosity of the upper jaw of the foetus are in the eighth or ninth year anterior to these parts. This same position with respect to the coronoid process and maxillary tuberosity is at a later date occupied by the second permanent molar; still later the third molar moves into the position formerly occupied by the first and second—at the age of eighteen or twenty the third molars are found anterior to the coronoid process in the mandible and under or somewhat anterior to the tuberosity in the maxilla. These changes have come about through a gradual absorption of the anterior border of the ramus coronoid and condyloid processes and a gradual addition to the posterior part of these processes as well as to the angle of the jaw. In this way the coronoid process which is at first situated over the crypts of the permanent molars becomes shifted to a plane behind them."

Humphrey[15] has also shown by the insertion of wires at the anterior and posterior borders of the ramus how accretion takes place on the posterior border at a very rapid rate and absorption on the anterior border at a much slower rate—these historical experiments of Humphreys' confirmed the observations of Hunter.

Briefly these experiments were as follows:

In a pig ten weeks old a hole was bored through the ramus of the lower jaw, midway between the fore and hinder edges; two wires were passed through it and secured, one encircling the anterior or coronoid portion and edge, and the other the posterior or condyloid part. After a month the pig was killed. The loop of the anterior wire was found projecting a quarter of an inch beyond the coronoid edge, showing that the bone had receded in that situation; whereas the loop of the posterior wire was buried more than a quarter of an inch deep in a notch in the condyloid part, showing that the bone had advanced in this direction, and to a greater extent than it had receded from the front.

In a pig thirteen weeks old a wire was placed round the left ramus of the lower jaw, encircling it entirely, and, of course, including the anterior and the posterior edges. Two weeks later a wire was passed through a hole bored near the anterior or coronoid edge of the right ramus and secured round that edge; and a second wire was passed through a hole bored near the hinder or condyloid edge and was secured round it. After three months the pig was killed. On the left side the loop of the wire projected half an inch or more beyond the coronoid edge; whereas behind it was buried in a deep notch in the condyloid edge, so deep that the head and angle of the bone reached to a plane more than an inch behind the wire. On the right side the anterior ring of wire was found in the tissue in front of the ramus and fell from it, having been disengaged by the absorption of the bone in this situation. Slight thickening and unevenness of the edge of the coronoid process mark where the wire had lain. The hinder ring was still held in place by the portion of bone which it encircled. It was nearly an inch from the hinder edge of the jaw.

In studying the growth of these bones, James C. Brash[16] has proven to his own satisfaction the accretion theory. The mandibles of maddered pigs show that accretion occurs on the lateral aspects and extends to the posterior border backwards and the condyle upward and backward. The main increase in height of the body of the bone is at the alveolar border and not at the lower border as was formerly believed. By superimposing accurate drawings of one-half the mandibles of pigs at various ages the directions of the growth were shown. The jaw grows in length forward and backward, the forward growth due to accretion on the anterior surface, the backward growth by accretion on the posterior border from condyle to angle and by the upward and backward growth of the condyle. As this upward and backward growth takes place a modelling absorption occurs. (The same as described by Hunter.)

The coronoid process grows upward and backward by accretion at the tip. The form of the anterior border of the ramus is maintained by appropriate absorptions. This absorption is not so extensive as to account for the entire backward movement of the ramus as was formerly believed, nor the only way in which room was made for the eruption of the molars. With the increase in height of the ramus it assumes a sharper angle in relation to the body. The pre-angular notch maintains its position moving slowly backward by accretion in front and by absorption at the back. The height of the body is due to the upward growth of the alveolar process which is associated with the erupted and erupting teeth.

The necessary space for the erupting molars is obtained by first, the rising of the teeth in the growing alveolar border in relation to the backward sloping anterior border of the coronoid process; second, by the upward and forward growth movement of the teeth themselves in the bone as evidenced by the continuous reformation and adjustment of the walls of the alevolar cavities and third, to a very minor degree (and not principally as was formerly supposed) by absorption of the anterior margin of the coronoid process.

Growth in width of the mandible as a whole is to a slight extent due to accretion over most of its lateral surfaces, but mainly dependent upon the oblique *outward* and backward direction of its growing posterior borders, including the condyles. This is demonstrated by horizontal superimposition of mandibles on the same basis as before.

The mandibles of the maddered pigs show that growth and absorption do take place, the new and growing bone showing white.

It may be felt by some that a comparison between man and other animals does not give a true picture of man's growth and development. In answer to this possible criticism, permit us to quote Krogman.[17] "The growth process in man is very similar to that in all animals—what differences exist are those of degree rather than of kind."

In any consideration of the denture the temporomandibular articulation must have a place. According to the studies of Humphreys,[18] during early childhood the joint undergoes no great change, the glenoid fossa remaining more or less flat or shallow with no eminentia articularis. This joint begins to change during the seventh year; its progress is slow until the tenth year when its development becomes greatly accelerated. By the twelfth year it is practically complete and has taken on its characteristic form. From the twelfth year on the greatest change is in the form and shape of the condyles which become more oblique in the adult than they were during infancy and early childhood.

The complicated movements of the jaw do not appear until the articular tubercle begins to develop. "All the complicated movements of the joint in man resolve themselves on analysis into two primary ones and to permit these the joint is really a double one, being divided into two compartments, by the inter-articular fibrocartilage, each lined with its own synovial sheath; in the upper compartments there takes place a horizontal gliding movement, and in the lower compartments, a vertical hinge movement."

A combination of movements acting at the same time in both compartments on either side but in a dissimilar manner gives the various movements characteristics of the human articulation.

The changes in jaw movement produced by the development of the articular eminence have produced changes in the occlusal plane of the teeth to compensate and insure that in all positions of the normal mandible the teeth shall be in contact in several places at once. There is an antero-posterior curve of Spee, with its maxillary convexity downward; which gives the required contact in simple protrusion. Rotation demands a like curve in a lateral direction. This is gained by the arrangement of the posterior teeth, so that the occlusal surfaces of the maxillary teeth look downward and outward, while the mandibular teeth look upward and inward. With normal articulation the mandible cannot be protruded until the jaws are opened sufficiently to disengage the overlapping incisors.

The Permanent Denture

Bödecker[19] has shown that we have structual changes such as the change in the form of the crown by abrasion. It can be observed that there is a gradual disappearance of the enamel of the occluding surfaces and that this brings about two separate and precise changes in the mouth. There is a change in the relation of the mandible to the maxillae and a change in the relation of each separately abraded tooth to the alveolar process.

The change in the relation of the mandible to the maxillae is purely structural and takes place when all teeth are abraded uniformly. They simply become increasingly shorter, causing the mandible gradually and slowly to approach the maxillae. This change reduces the length of the face and is most evident in the edentulous mouth where the chin and nose seem almost to meet.

John Hunter[20] pointed out, "The alveolar processes of both jaws should rather be considered as belonging to the teeth than as a part of the jaws; for they begin to be formed with the teeth, keep pace with them in their growth, and decay and entirely disappear when the teeth fall out; so that if we had no teeth, it is likely we should not only have no sockets, but not even these processes in which the sockets are formed; for the jaws can perform their motions, and give origin to muscles, without either the teeth or alveolar processes. In short, there is such a mutual dependence of the teeth and alveolar processes on each other that the destruction of the one seems to be always attended with that of the other."

When there is a change in the relation of the individually abraded teeth to the alveolar process, it is attended by an alteration in the histological structure of the accompanying roots. In the tooth of a young individual in its relation to the alveolus the space between the roots and surrounding bone is comparatively large. It is filled with a thick peridental membrane or pericementum. In young individuals the layers of cementum covering the roots of the teeth are found thin. With advancing years, layer after layer of cementum is deposited on the surfaces of the root and new bone is formed in the alveolus. This gradually diminishes the size and depth of the socket and this encroachment from two sides reduces the space around the root thus causing the peridental membrane to become thinner.

When the individual teeth are abraded and nature counteracts this loss of tissue by the growth of cementum about the apices and at the root bifurcations the tooth is forced occlusally from its socket in order that it may be kept functioning with its antagonist. Thus with advancing age the teeth are slowly extruded from the surrounding bone.

A second change to be found is the change in the form of the pulp chamber by deposition of secondary dentin. This occurs more commonly in the teeth of older individuals. In the molars of a young person the pulp chamber is roughly a cubical space in form and takes up a great part of the center of the crown, the pulpal horns ascend from its upper angles and are easily exposed. However, as the individual becomes older, the crowns of the molars abraded, chemical and thermal stimuli are communicated to the pulp from the surface of the exposed dentin. With this stimulation the odontoblasts renew their activity and secondary dentin is formed in these areas.

In the above, mention was made of the possible extrusion of abraded teeth from their alveoli, accompanied by or perhaps caused by deposits of cementum at the apices and bifurcation of the roots. The entire anatomical relations of such apices are changed by the added cementum. In the young individual the apex of a tooth has one large foramen as an entrance of the blood vessels and nerves for the supply of the pulp. In an older individual, the apex of the tooth usually has numerous infinitesimal foramina. In the young individual the vessels and nerves of the tooth entering the large apex are often separated slightly; when cementum is laid down in this area, it also forms between the individual vessels and nerves and the large apical opening is transformed into numerous canals. A sieve-like appearance is given to the tip of the root of an old tooth. Another explanation is this: new canals are formed in the root, by resorption, which then transmit vessels and nerves. They may not be at the extreme tip of the root and may often show widely scattered foramina. The final change is a retraction of the gingivae. This is found in the mouths of all old people, even where no evidence of pathology is found to exist.

An interesting view of Gottlieb, which may explain this extrusion of teeth, is that after the thirteenth year the teeth do not discontinue the movement of eruption but erupt in various mouths at various times.

Kronfeld's observations[21] show that there are, throughout life, various "successive stages" of eruption. Thus he points out that the tooth under nonpathologic conditions continues to move occlusally, but in later life at a very slow rate of speed. During this slow movement, the gingival tissues are separated from the tooth at the bottom of the crevice. Abrasion continuously keeps wearing off the crown. Cementum is being deposited on the surface of the root. As long as this goes on slowly and evenly, they are, according to him, natural signs of approaching old age.

Besides the natural abrasion of the occlusal surfaces, there is the abrasion at the contact points reducing the mesiodistal diameter of the teeth. The teeth are constantly slipping in a mesial direction reducing the size of the arches.

These views of Gottlieb, Orban and E. Muller are challenged by another group of investigators of whom Bauer, Haupl, and Lang agree that an epithelial attachment to the enamel occurs when the occlusal line is reached by the teeth; but they believe that that condition is physiologically normal only at the time and any further detachment borders on the pathological.

To all of us who are interested not only in the beginning of the permanent dentition, but also in what is happening to it at every age and stage physiologically and pathologically, this line of investigation on later development, which seems to have been neglected study, is very timely indeed.

We are reminded by Friel[22] that "With the cusps of molars and premolars being worn away the jaws come closer and closer together. The mandible is swung forward mechanically so that the mandibular incisors wear more heavily on the maxillary incisors and the edges are worn away. The more the molars are abraded, the more edge to edge the occlusion of the incisors. With these changes it is shown that the typical relations of the first permanent molars are not the same for all ages, that occlusal phenomena are changing from childhood to old age and these phenomena reflect the vital processes of the supporting structures of the teeth.

In conclusion we feel that there is no better way to show that the development of the denture and the growth of the jaws is an indivisable phenomenon than to study briefly the series of photographs of the specimens so beautifully demonstrated by Dr. Noyes. A critical review of them from time to time will keep fresh in your minds as orthodontists the undeniable fact that the human denture is never a finished product but an organ that is constantly changing from birth to death ever keeping pace with the demands that are made upon it both by a rapidly changing individual and slowly changing civilization.

At birth all of the teeth with the exception of the second and third permanent molars are developing in the jaws. They occupy the whole of the maxilla from the floor of the orbit to the occlusal plate and almost completely fill the body of the mandible. The ramus is almost on the same plane as the body of the mandible, there being little angular development. With the beginning eruption of the deciduous teeth at about six months we find definite evidence of vertical growth in the lower part of the face. The angle of the mandible has become more pronounced and a few months later we find with the partial calcification of the first permanent molar and the upward growth of the deciduous molars that this bone assumes a more characteristic form. At a year and a half we have a further increase in the ánteroposterior depth of the jaws caused in part by the development of the crypts of the first molars. Note here the relation of these teeth to the anterior border of the ramus. At three years we have the completion of the deciduous denture, probably as perfect a masticatory apparatus as the individual will ever enjoy. The normal functioning period of this machine is approximately three years when through physiological root absorption it begins to disintegrate and the succeeding teeth, beginning with the lower incisors, force themselves to position, this wedging power influencing the lateral development of the jaws. The first permanent molar now takes its position in the arch. You will now find that the second permanent molar has taken the position formerly occupied by the first under the ramus of the mandible. The angle becomes less obtuse and the coronoid notch takes on a more characteristic form. The upper second permanent molar has begun its journey backward, downward, and outward, thus adding to the depth of the maxilla. Between this stage and the next comes a tremendous spurt in the growth of the jaws. The vertical height has increased enormously, as shown by the fact that the root of the upper cuspid now occupies the position formerly held by the crown. New bone has been deposited on the lower border of the body and the angle of the mandible increasing its depth as can be seen from the new relation of the inferior dental canal. In the fully developed dentition of the young adult length has been added to the mandible so that the third molar now occupies the same relation to the anterior border of the ramus as that previously held by the second and before it by the first molar. The ramus together with the coronoid and condyloid processes have developed in all directions save forward. The maxilla has developed downward, forward and outward as previously described. The step from here to the fully formed adult denture is not so much a matter of growth in size as it is of coordination, a settling down to a long period of useful function.

Twice, then, in the life of the individual we have seen the perfect functioning, perfectly developed masticatory machine. At the completion of the deciduous denture which has undergone a rapid period of growth, a short period of active use and then a breaking up and reorganization from which slowly emerges the permanent denture built on the same foundation, of the same materials, and for the same purpose but with added strength and stamina. It has been said that nothing in nature ever stands still; so it is with the normal denture, though it enters a period of gradual decline it will ever be found: "In harmony, in form, and position with and in proper relation to, all other parts of that great structure according to the inherited type of the individual."

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