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The influence of senescence on craniofacial and cervical morphology in humans

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Summary: This study discusses the morphologic evolution of the cranio-facial and cervical bone structures throughout life. A cephalometric study was made on lateral radiographs. The population studied included 84 males and 102 females. Ages ranged from 21 to 101. The cranial structures, superior facial structure, mandible and cervical vertebral column were successively examined. The anteroposterior diameter of the calvarium does not seem to undergo any modification during life. On the other hand, a highly significant increase of the thickness of this structure can be noted. The upper facial structure presents some modification, namely a significant increase of its posterior height. The palatine processus seems to change direction and pivot downwards and forwards. The maxillary sinus does not undergo any changes. The mandible, which is stable in its major axes, shows more malleable sectors which are more especially situated at the level of its body. The study of the cervical vertebral column reveals a loss of overall height, and an increase in the lordosis. The most numerous and most evident morphologic modifications were observed around the age of fifty in both males and females. The fact that these transformations are always commoned and greater in the latter reveals the plausible influence of the menopause. It appears that bone structures of membranous origin are the site of significant modifications compared with structures of endochondral origin, which benefit from a greater stability.

L'influence de la sénescence sur la morphologie crânio-faciale et cervicale chez l'Homme

Résumé : Le but de ce travail est de mettre en évidence l'évolution de la morphologie des structures osseuses crânio-faciales et cervicales chez l'Homme au cours de la vie. Une étude céphalométrique a été réalisée à l'aide de clichés radiographiques norma lateralis. La population de recherche était constituée de 84 sujets masculins et de 102 sujets féminins. L'échelle globale des âges s'étendait de 21 à 101 ans. Les structures crâniennes, le massif facial supérieur, la mandibule et la colonne vertébrale cervicale ont été examinés successivement. Le diamètre antéro-postérieur de la calvaria ne semblait pas présenter de modifications au cours de la vie. En revanche, on observait une augmentation hautement significative de l'épaisseur de cette structure. Le massif facial supérieur présentait quelques modifications et particulièrement une augmentation significative de sa hauteur postérieure. Les processus palatins semblaient changer de direction et pivoter vers le bas et vers l'avant. Le sinus maxillaire ne présentait aucune modification notable. La mandibule restait stable dans ses proportions générales, mais présentait des secteurs plus malléables, situés surtout au niveau du corps. L'étude de la colonne vertébrale cervicale montrait une perte de hauteur globale et l'augmentation de la lordose. Il faut noter que les modifications les plus nombreuses et de plus grande amplitude s'observaient aux alentours de la cinquantaine, tant chez l'homme que chez la femme, mais qu'elles étaient toujours plus nettes chez cette dernière, ce qui évoque l'influence probable de la ménopause. Il apparaît que les structures osseuses d'origine membraneuse sont le siège de transformations plus importantes que celles d'origine enchondrale qui bénéficient d'une plus grande stabilité.

Key words: Senescence — Cranio-facial morphology — Human evolution — Mandible — Calvarium

The subject of this study was the morphologic changes in craniofacial and cervical bone structures throughout life. During the ontogenic phase, bone modifications in the head and neck can be observed and have been reported in many studies [3, 4, 7, 17, 19, 26, 38]. However, this is not so for the adult and subsequent senescent phases, whereas mechanomorphosis of these bone structures, both cra-

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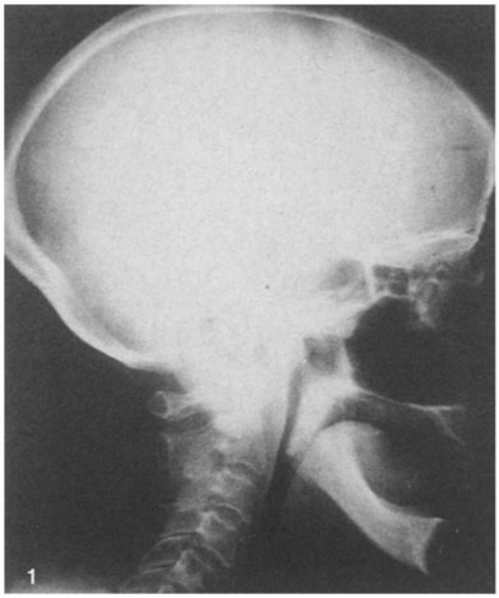
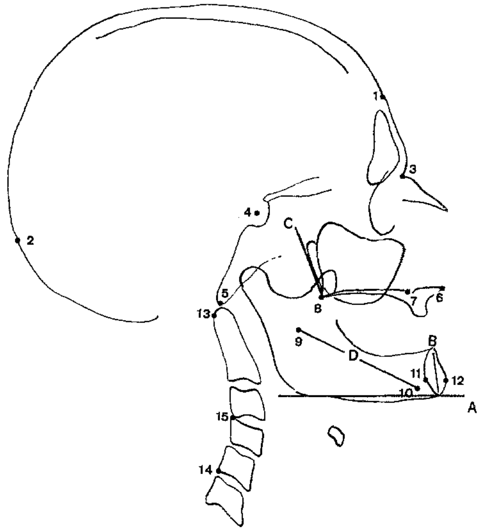
Relevant points and axes for Figs. 2-8 and 14

1, most anterior point of vertical part of frontal bone; *2,* most posterior point of occiptal squama; *3,* nasion (Na); *4,* point S; *5,* basion (Ba); *6,* anterior nasal spine (ANS); *7,* anterior palatine canal (APC), posterior margin; *8,* posterior nasal spine (MNS); *9,* spine of lingula (SL); *10,* mental foramen (MF); *11,* genion (Ge); *12,* pogonion (Pog); *13,* posterosuperior pole of odontoid process of axis; *14,* posteroinferior pole of image of vertebral body of C5; *15,* most anterior point of posterior border of cervical spine; *A,* mandibular plane of Downs; *B,* main axis of mandibular symphysis; *C,* anterior pterygoid line (Thilloy); *D,* neurovascular axis SL-MF





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Figs. 1, 2
1 Cranio-facial and cervical bone structures as shown in lateral radiograph. **2** Anatomic and constructed cephalometric points

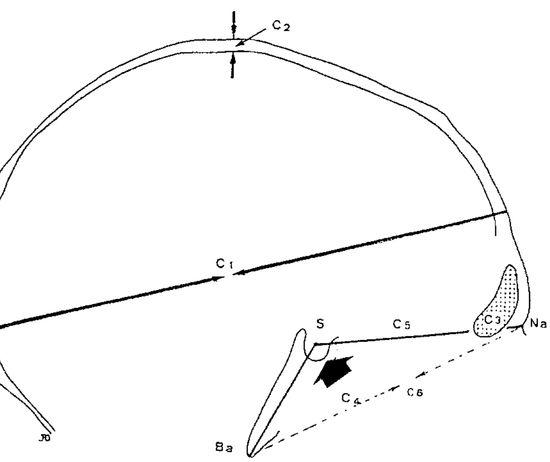

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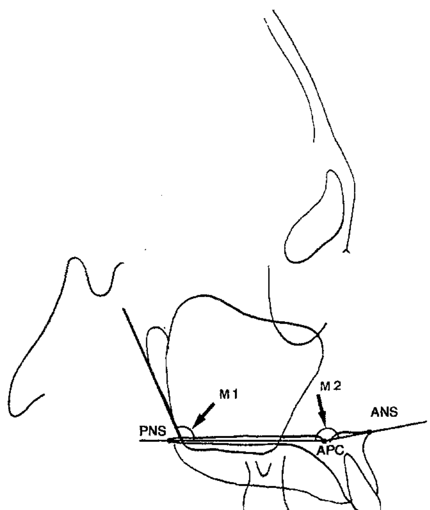
Fig. 3
Cranial structures

Figs. 4, 5
4 Superior facial structures. **5** Anterior and posterior dimensions



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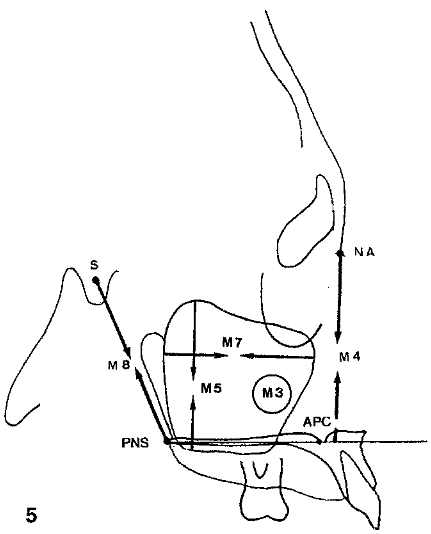

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nial and facial, continues on a lifelong basis [20, 2]. It is directly linked to the molding ability of orofacial function and its variations. This observation is in agreement with the theories maintained by Moss [22, 25, 32, 33] according to which skeletal morphology is the result of the action of soft tissues in general, and by Couly [6, 7] who revealed their modeling effects on their skeletal environment. This morphogenetic process [11, 15, 16, 17, 28, 30, 31, 34, 37] continues throughout life. However, functional involution sets in progressively and is accompanied by various parafunctions, resulting in the appearance of a neuropathology of the elderly subject [1, 5, 8, 18, 23, 35, 36, 40, 41]. The modeling action will hence be modified and lead to a morphologic evolution of the bone structures. To these modifications of the modeling process can be added the signs of ageing of the bone tissue itself [12, 13, 14, 21, 24, 42]. This brings about alterations of its physical and chemical properties which modify its responses when subjected to mechanical constraints. In addition, the bone is not only plunged into a new functional context, it is also faced with the problems of the menopause and the male climacteric which create different conditions of hormonal impre-

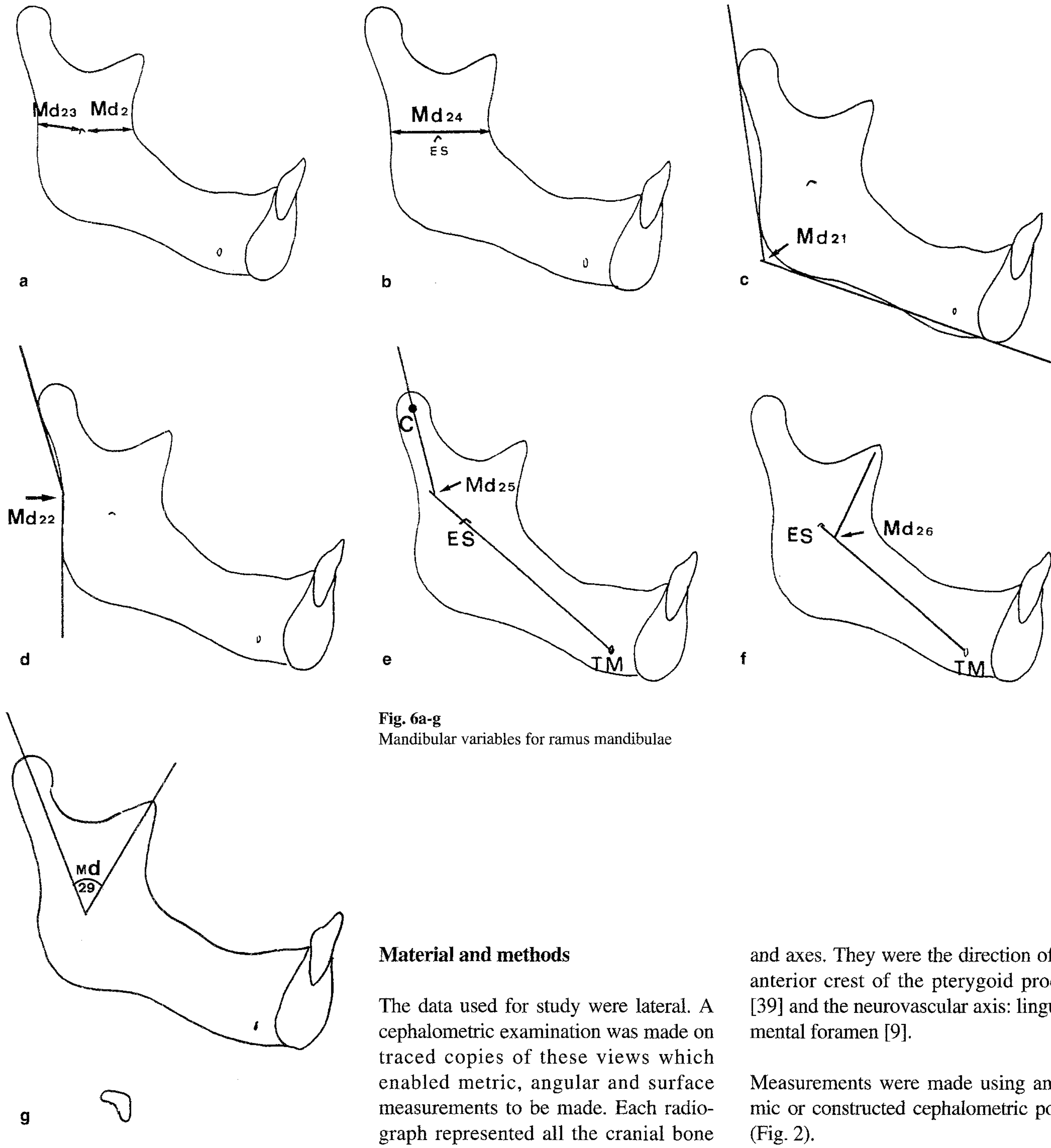


Fig. 6a-g
Mandibular variables for ramus mandibulae

gnation. Given these conditions, interrelated modifications of the specific morphology of bone units can be expected to be observable throughout life. It is proposed in this study to investigate successively the morphologic variations of the cranial sites (calvarium and skull base), the superior facial structures, the mandible and the upper cervical vertebral column (Fig. 1).

Material and methods

The data used for study were lateral. A cephalometric examination was made on traced copies of these views which enabled metric, angular and surface measurements to be made. Each radiograph represented all the cranial bone structures, including the mandibulofacial, hyoid and spinal structures down to the 6th cervical vertebra. Each of these structures was studied to reveal its morphologic evolution during the life span. Several observations by different authors [9, 10, 39] were employed for this cephalometric study. They had reported the stability of certain bone structures during the ontogenic phase, postulating their stability during later life and therefore their suitability as reference points and axes. They were the direction of the anterior crest of the pterygoid process [39] and the neurovascular axis: lingula - mental foramen [9].

Measurements were made using anatomic or constructed cephalometric points (Fig. 2).

Variables studied (Figs. 3-8)

The variables used for study of the cranial structures (Fig. 3) are labeled C and are the following: C1, the sagittal diameter of the calvarium, C2, the thickness of the calvarium at its summit, C3, the surface of the frontal sinus, C4, the measurement of the spheno-occipital angle (Na-S-Ba), C5, the measurement of the distance Na-S, and C6 of the distance Na-Ba.

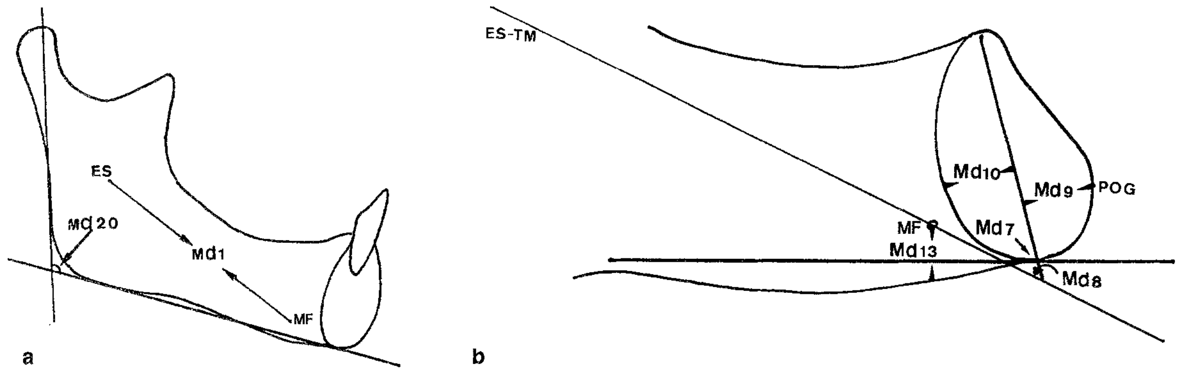


Fig. 7a, b
Variables for the body of mandible

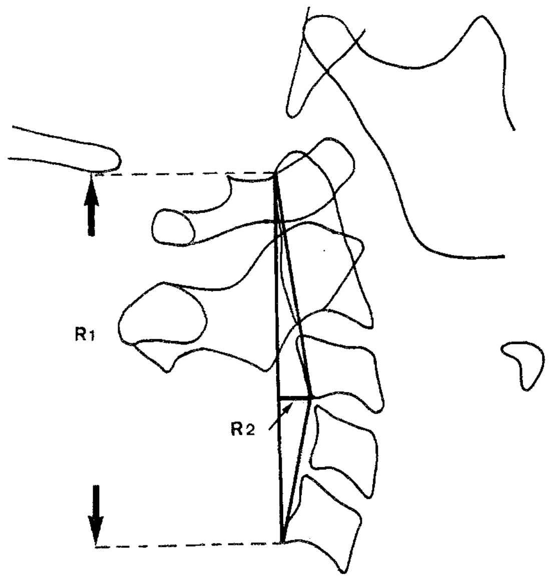


Fig. 8
Vertical dimension of cervical vertebral column

The variables used for the study of the superior facial structures (Figs. 4, 5) are labeled M: M1 being the angle formed by the plane of the palatine process and the anterior line of the pterygoid process, M2, the angle formed by the plane of the palatine process and the os incisivum (ENA-CPA-ENP), M3 the surface of the maxillary sinus, M4 the vertical dimension of the anterior portion of the superior facial structures (distance Na - plane of the palatine process), M5 the vertical dimension of the maxillary sinus, M7 the sagittal dimension and M8 the size of the posterior portion of the superior facial structures (distance ENP-S).

The mandibular variables are labeled Md and are as follows:

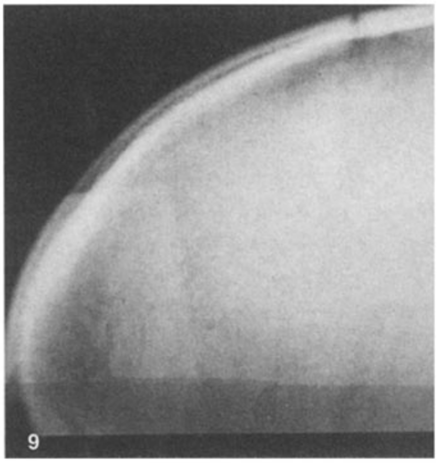
For the ramus mandibulae (Fig. 6a-g): Md2 is the distance from the extreme posterior point to the anterior edge of the ramus to point ES; Md23, the distance from the extreme anterior point of the posterior edge of the ramus to point ES; Md24, the minimal distance between the anterior and posterior edges of the ramus; Md21, the angle formed by the mandibular plane and the tangent to the inferior portion of the posterior edge of the ramus and the back of the condylar process; Md22, the angle formed by the tangent to the posterior pole of the mandibular condylar process and the tangent to the posteroinferior portion of the ramus; Md25, the angle formed by the major axis of the condylar process and the straight lingula - mental foramen line; Md29, the angle formed by the major axes of the condylar process and the coronoid process.

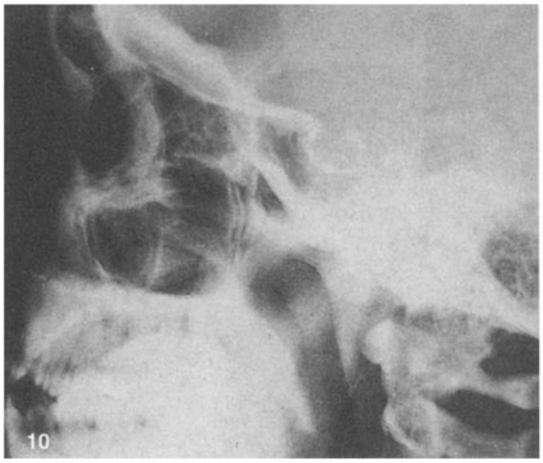
For the body of the mandible (Fig. 7a, b), the variables studied were: Md1, the distance from the lingul to the mental foramen; Md20, the angle (between the mandibular plane and the tangent to the inferoposterior portion of the ramus); Md13, the distance from the basilar edge to the mental foramen taken perpendicular to the mandibular plane; Md7 and Md8, (angles of the major axis of the mental symphysis to the mandibular plane and the lingula mental foramen axis respectively); Md9 and Md10, the respective distances from the major axis of the mental symphysis to the pogonion point (PG) and to the extreme posterior point of the mental symphysis; finally Md11, the distance between the PG and the mental foramen.

As regards the cervical vertebral column (Fig. 8) the R1 variables were studied, the distance from the superoposterior pole of the odontoid process of the axis to the postero-inferior pole of the vertebral structures from C5 and R2, the apex of the vertebral arch enabling the degree of cervical lordosis to be assessed.

Sample population

The recruitment of subjects studied was from a private odontology practice and from University Hospital and dental clinics. The 206 subjects was composed of 84 males and 122 females whose ages ranged from 21 to 101 (21 to 89 for males and 21 to 101 for females).





Figs. 9, 10
9 Calvarial morphology. **10** Skull base

Determination of samples

A study was planned of the possible interrelation between the involution of the skeleton and age according to gender. The original file, identified as A, was composed of 84 male subjects and 122 female subjects listed in order of age. It was divided into two files, one for males (file H) and the other for females (file F). File H was subdivided into three groups: subfiles D for males from 21 to 49 (18 subjects), E for males from 50 to 69 (36 subjects) and G for males of 70 and over (30 subjects). In the same way file F was subdivided into subfiles I for females aged between 21 and 49 (52 subjects), J for females from 50 to 69 (28 subjects) and K for females of 70 and over (42 subjects).

This division into subfiles allows the following comparisons : H and F, comparisons of a general nature revealing the possible interrelation between skeletal modifications and gender. Comparisons between D and E, D and G, E and G, based on the male population, allow comparison between different age groups and the revealing of a possible relationship between this factor and modifications of skeletal morphology in the male. Comparisons between I and J, I and K, J and K allow the same observations in females. Files D and I, E and J, G and K compare individuals of the same age but of different gender to reveal a possible relationship between skeletal modifications and gender at different stages in life. Comparison between subfiles I and J, reveals any potential relationship between skeletal involution and the menopause.

Statistical methodology

As previously stated, the variables studied were a metric, angular and surface nature. Since the value of the angular variables is barely influenced by differences in height, this type of variable can be used as it stands. Variables of a metric and surface nature, being influenced by the varying height of individuals, were used after conversion to an identical unit which is the average value of a linear variable selected as reference, in this case the length of the cranial base NaBa. This solution, which simply produces a change of unit, allows the comparison of averages (Student's reduced discrepancy test or t test) and variances (Snedecor's F test) between subfiles composed of variables of identical nature. For the statistical study, a descriptive analysis of the different variables in the various files was carried out, together with a comparative analysis of the different subfiles by means of comparison between the averages and the variances, a correlative analysis of the different variables with age, and a correlative analysis between the variables.

Results

The results are presented in four parts: cranial structures (calvarium and skull base), the superior facial structures, the mandible (ramus and body) and the cervical vertebral column.

Cranial structures

Calvarium (Fig. 9). Examination of the calvarium was performed by the study of variables C1, C2 and C3. Smaller in the female than in the male, C1 (anteroposterior diameter of the calvarium) shows very similar average values in both the three male and the three female samples. This structure does not seem to undergo any modification during the lifetime of either sex. Moreover, no correlation of this variable with age in either file H or file F. On the other hand, C2 (thickness of the calvarium) shows significant differences. In the male, a *highly significant increase of this thickness,* can be noted between samples D and E, i.e. between young and middle-aged males. This modification seems to take place around the age of fifty. It eventually stabilises and then seems to progress at a very slow pace to finally show an extremely significant difference between the two samples representative of the two extremes of adulthood. The preponderant positive correlation between age and this variable in file H (R=0.482) confirms this evolution. In females a thickening is noted on a larger scale. An extremely significant difference is noted between samples I and J. As in males, this thickening seems to become maximal by around the age of fifty and to barely progress from then on. The positive correlation between age and C2 in file F is extremely preponderant (R = 0.641). The surface of the frontal sinus (C3) does not seem to be related to the ageing process in either sex.

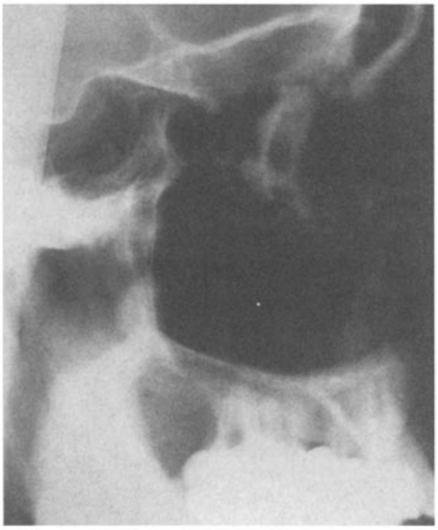


Fig. 11
Superior facial structures

Skull base (Fig. 10). The basicranial structures were studied by means of variables C4, C5 and C6. The spheno-occipital angle (Na-S-Ba) (C4), which is similar in males and females, appears to remain stable on a lifelong basis. The anterior portion of the base of the cranium (distance Na-S) does not differ between the two samples in either males or females. However, this part of the cranial base seems to show a slight reduction which is evenly spread out throughout life. The distance Na-Ba (C6) does not present any significant differences in the male, though it exhibits a regular, age-linked decrease. In the female, this decrease occurs on a much larger scale. As in the male, it seems to establish itself gradually throughout life, but accelerates around the seventh decade. The existence of a moderate, age-linked, negative correlation in the male (R=-0.243), more significant in the female (R=-0.360) confirms the conclusions of the comparative study. What is happening? Is there a migration from the basion point or the nasion point or from both? In this context the decrease in C5, even if slight, clearly exists in both sexes and is more evident in the female than the male. It can be imagined that, with age, a backward migration of the Na point and a decrease in the distance Na-Ba could confirm the existence of remodeling in the frontonasal area.

Superior facial structure (Fig. 11)

The evolution of the overall dimensions of this facial edifice was studied by means of variables M4 and M8. The vertical dimension of the anterior portion of the superior facial structure (M4) does not show any significant variation in either males or females. This region benefits from a relative stability, confirmed by the correlative study which does not establish any relationship between age and the evolution of this dimension. However, the height of the posterior portion of this facial structure (M8), which is stable in the male, presents a very significant increase in the female towards the age of fifty. The correlative study confirms the findings of the comparative tests since the increase in this dimension is not age-linked in the male (R=0.049) but is significantly so in the female (R=0.242). At this stage of life a very significant posterior distancing of the nasal spine from point S takes place. The palatine process, which are stable in their anterior portion (M4), seem, particularly in the female, to change direction and pivot downwards and forwards.

Study of the palatine process and incisive bone corresponds to variables M1 and M2. The angulation of the palatine process in relation to the anterior line of the pterygoid process [39] does not present any noteworthy variations in the male but has a significant tendency decrease in the female towards the age of fifty. The evolution of this variable thus corroborates the observations made for M8. The reduction of this angle tends to confirm the foreward pivoting of the palatine bones. Conversely, the absence of significant differences observed for M2 in the various samples in both males and females demonstrates the relative invariability of the angulation of the incisive bone in relation to the palatine process. If an attempt is made to synthesise these observations, then if there is an adaptation to new functional conditions that occur during life, it appears in a more evident manner in the palatine process and the anterior region of the superior facial structure benefits from a relative stability.

The evolution of the maxillary sinus corresponds to the study of variables M3, M5 and M7. The average values of M3, the visible surface of the sinus, remain very similar in the various samples and show very little evolution of this facial cavity throughout life in either sex. These average values would seem to decrease simultaneously in males and females. Although more distinct in the latter, this modification remains negligible in all cases and never reaches the threshold of significance of the comparative tests in the different age groups.

The study of M5, the variable quantifying the vertical dimension of the maxillary sinus and of M7, quantifying its sagittal dimension, does not reveal any sign of evolution in either sex. The study of these three last variables demonstrates the stability of the proportions of the sinus. Nor does the correlative analysis reveal any signs of evolution. It would therefore seem, within the limits of this investigation, that the functional involution that gradually sets in during existence and, in particular, the involution of mastication caused by the loss of teeth and by the diminished performance of the muscles has only a slight influence on the size of this facial cavity.

Mandible (Fig. 12)

The studies of the ramus and of the body of the mandible are successively set out.

Ramus. The overall dimensions of the ramus were assessed by variables Md2, Md23 and Md24.

The study of Md2 shows that the distance from the lingula to the anterior edge of the ramus does not undergo any modification in either sex throughout life. Similarly, Md23, the distance from the posterior edge of the ramus to the lingula, remains stable. Lastly, Md24, the total anteroposterior breadth of the ramus closely linked to the two previous measurements, does not show any significant modifications. A decrease, however, can be noted in the average values of this overall value of the ramus; it is slight but real and even reaches the threshold of significance in females towards the age of seventy.

However, the ramus does not seem to undergo any noteworthy modifications in its anteroposterior dimensions with increasing age, as confirmed by the

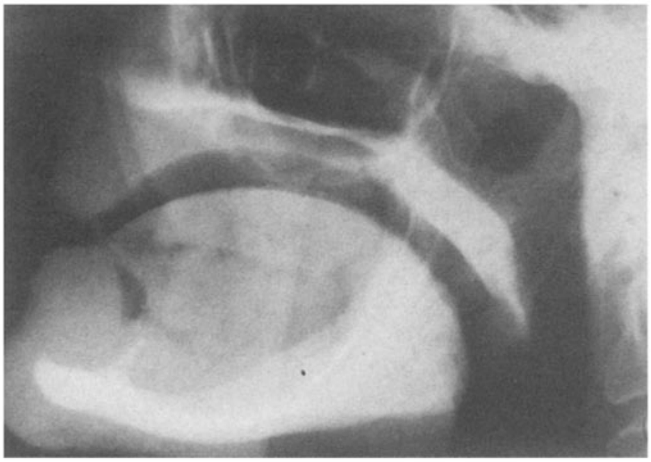


Fig. 12
Mandibular morphology

absence of any significant correlations between age and the three last variables.

The characteristics of the condylar process region are assessed by variables Md21, Md22 and Md25. The condylo-mandibular angle assessed by Md21 does not show any noteworthy variation in either sex throughout life. Moreover, it is not age-linked in any of the files of the correlative study. This means that open or closed angles are met in both the young and the elderly age groups. Examination of Md22 reveals a modification in the male reaching the threshold of significance and a slightly more substantial modification in the female, resulting in the appearance of a certain concavity on the posterior edge of the ramus. This zone would therefore appear to be the site of remodeling activity corresponding to a process of reabsorption. This modification can be compared with the slight decrease of the anteroposterior dimension of the ramus revealed by the study of Md24. Indeed, there is no correlation between Md22 and Md21, which signifies that the angle determined by the straight lines tangential to the condylar process and to the postero-anterior portion of the ramus can evolve without the condylo-mandibular angle undergoing any modifications. It is therefore not a tilt of the condylar process structure onto the lower part of the ramus, but a site of reabsorption producing a cavitation effect at this level. Finally, the tilt of the major axis of the condylar process in relation to the axis of the inferior alveolar neurovascular canal does not reveal any modification. Therefore, apart from the appearance of this resorption site on the posterior edge of the ramus, this portion of the mandible seems to remain relatively stable throughout life and, in particular, the sagittal tilt of the condylo-lingular structure.

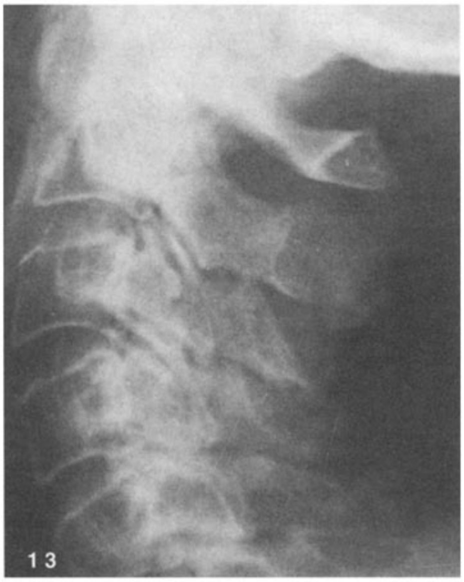
The tilt of the major axis of the coronoid onto the neurovascular axis ES-TM (Md26) is only slightly subject to modifications; apart from a slight erosion of its extremity which could lead to a displacement towards the back of its summit, the coronoid process remains generally stable throughout life. As for the sagittal angle it forms with the major axis of the condylar process (Md29) no variation is revealed. This confirms the stability of the two aforementioned structures. The condylo-coronoid area therefore appears to remain stable throughout life in both sexes.

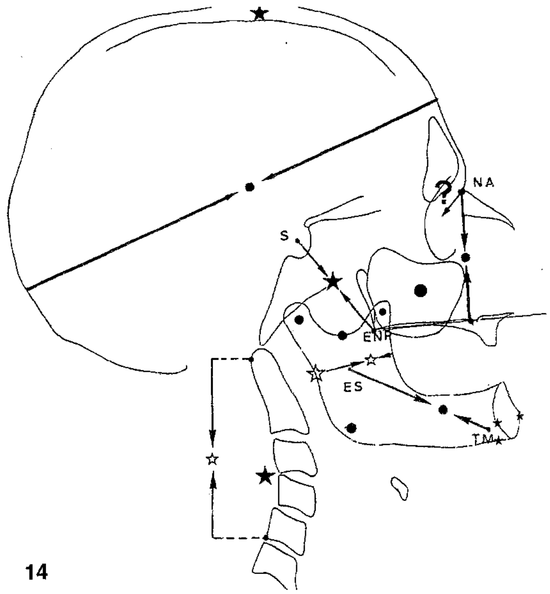
Body. The Md1 variable corresponding to the lingula - mental foramen distance shows great stability all through life. Again, the actual region of the mandibular angle as such (Md20), does not seem to be the site of significant modifications, which is confirmed by the correlative study. The variable Md13 illustrates the morphology of the basilar ridge of the mandible in the anterior region. The distance from the basilar ridge to the mental foramen (Md13), which is considered as a stable landmark, increases in both sexes. Although it does not reach the threshold of significance in the male, the increase in this distance appears in a linear manner throughout life. Conversely, in the female it increases in a very significant manner around the age of fifty to remain subsequently stable. It therefore seems that the basilar edge of the mandible, in its anterior portion, is the site of an appositional process in both sexes but particularly in females around the age of fifty. These findings are confirmed by the correlative study ($R = 0.269$).

In the symphyseal region, several variables were selected which illustrate the morphologic evolution of this region.

The two variables Md7 and Md8 assess the tilt of the major axis of the mental symphysis on the mandibular plane (Md7) and on the lingula - mental foramen axis (Md8). Both show the amplification of this tilt with increasing age in a very significant manner. They show a significant correlation for Md7 ($R = -0.215$) and a very significant correlation for Md8 ($R = -0.348$), both negative values confirming that the reduction of the angle is linked with the ageing process.

Also in the symphyseal area, the evolution of the distance between the major axis of this structure and the pogonion point (Md9) was followed, then with the genion point (Md10). Stable in the male, Md9 shows a highly significant increase in the female towards the age of fifty, which continues in the higher age groups. This evolution is confirmed by the correlative study ($R = 0.202$) and seems to be related to an appositional bone process in the region of the pogonion. As for Md10, also stable in the male, it progressively increases throughout life in the female and ends up establishing a significant difference between the age groups at either end of the spectrum. The region of the mental spine in the female is the site of an ossification process which increases with age. Moreover, a positive correlation exists between the increase of this distance and age, ($R = 0.216$), unrelated to a precise age group, demonstrating the progressive nature of this evolution previously revealed by the comparative study. The distance from the pogonion point to the mental foramen (Md11) increases slightly, but the difference between age groups does not reach the threshold of significance. However, there seems to exist a tendency towards bone apposition in this region.





Figs. 13, 14
13 Severe cervical lordosis in sixty-year-old female. **14** Morphologic evolution of cranio facial and cervical bone structures

Cervical vertebral column (Fig. 13)

The study of variable R1, measuring the dimensions of the cervical spine, reveals a loss of overall height in both males and females. In the male the reduction in height is evident and regular during life and results in a very significant difference between the young and the elderly subjects. In the female, the evolution shows a different profile : the loss of height appears abruptly towards the age of fifty to continue at a slower pace. This evolution finally results in a highly significant difference between the age groups at either end of the spectrum and shows a more substantial cervical compression than in the male. This difference between the sexes is also revealed by the correlative study, where a correlation which is moderate in the male (R = -0.251) and significant in the female (R = -0.488) can be noted.

The extent of cervical lordosis is measured by variable R2 which indicates the apex of the spinal arch. Already slightly more pronounced in the female than in the male in youth, its evolution during life does not appear to be identical in both sexes. It increases slowly in the male until approximately the seventh decade and then accentuates significantly to result in a very marked difference between the age groups at either end of the spectrum. In the female, the most substantial increase takes place much earlier, around the age of fifty; it subsequently continues to produce a highly significant difference between the youngest and the oldest subjects. This is therefore an important modification of spinal morphology which cannot be avoided by either sex. In the male as in the female, the spinal apex is strongly influenced by the ageing process; these positive value correlations (R = 0.321 in the male and R = 0.382 in the female) confirm that the accentuation of cervical lordosis is age-linked.

Discussion

Senescence appears as a stage of development. It is a biologic phenomenon continuing the work of the previous stages - embryogenesis, the growth and maturation of structures - and these main guidelines can also be found in the evolution of the craniofacial and cervical complexes. Among these can be recognized the craniomandibular structures stemming from the primitive chrondocranium, serving as a basis for the development of surrounding structures of membranous origin and of an adaptative nature.

The extremely prepotent and unchanging correlations between certain mandibular structures and the cranial base reflect their stability and genetic relationship. In this instance it concerns the correlations between the length of the neurovascular lingula - mental foramen distance and the angulation of the cranial base on one hand and between the total length of the mandible and the distance Na-Ba on the other. It is possible that remodelling occurs with age in the region of point Na, but it is a point at the limit of the facial structure and the basis cranii and of which the evolution seems to be more probably linked to a remodeling of the frontonasal region.

Around this craniomandibular structure, which is generally stable morphologically, more malleable and adaptive structures are formed (Fig. 14), notably the calvarium whose thickness increases considerably with age. Another structure of an adaptative nature is the superior facial structure. This buffer area situated between the mandible and the skull base shows stable elements such as the maxillary sinus and the premaxilla. However, its adaptative response to the new functional context which is established during life is demonstrated by a modification of the direction of the palatine process and by a remodeling of this region. The mandible, which is stable in its major axes and in its proportions, shows more malleable sectors capable of modification. They are more especially situated at the level of its body. Indeed, remodeling is noted in the symphyseal region in its basal portion and in the region of the basilar ridge in its anterior portion. These structures are both sites of a bone apposition process which can significantly modify the mandibular profile.

Conversely, no significant variances were revealed as regards the ramus, apart from a remodeling of its posterior edge associated with a slight decrease of its sagittal dimension: the main functional structures of the mandible, coronal and condylo-lingular structures do not appear to be subject to significant variations.

Morphologic modifications of the skeleton of the head and neck therefore occur throughout life. The possibility of bone remodeling implies that if the elderly are subject to osteolysis, they are also capable of osteogenesis. The combination of these two processes, whether concomitant or not, results in a new craniofacial and cervical morphology [30, 31]. *The most numerous and most evident morphologic modifications are observed around the age of fifty in both males and females.* The fact that these transformations are always more numerous and greater in the latter, and that they coincide with the fifth decade, reveals the plausible influence of the menopause. Finally, it appears that bone structures of membranous origin are the site of significant modifications compared with structures of enchondral origin, which benefit from greater stability.

Conclusions

All the findings made during this study confirm an extremly close relationship between function and structure in all stages of life. The neuro-musculature, together with the vascular, neural and glandular elements which make up the formative organs carrying out the modelling process on the skeletal frame, are subject to the ageing process. This can be observed at all levels of integration of living matter, be it molecular, cellular, tissular or organic, and as repercussions on the formative ability of these elements. Morphologic variations of the cranial, facial and spinal bone elements have hereby been revealed. However, we are convinced that fonctional evolution also causes architectural modifications of the cranio-facial and cervical edifice and results in significant modifications of the interrelation between the bony elements.

References

1. Aiche H, Mariani P (1982) Problèmes biologiques posés par l'édenté total âgé. Quest d'Odont Stom 26: 373-379
2. Basset CAL (1972) A biophysical approach to cranio-facial morphogenesis. Acta Morph Neerl Scand10: 71-86
3. Bjork A (1955) Cranial base development. Am J Orthod 41: 198-225
4. Brichard M (1969) La normalité et la croissance crânio-faciale. Rev Stomatol Odontol 93: 19-26
5. Cheron G, Desmedt JE (1981) L'évaluation électrophysiologique du vieillissement nerveux. Rev Geriatr 6: 221-225
6. Couly G (1977) La dynamique de croissance céphalique. Le principe de conformation organo-fonctionnelle. Act Odontol Stomatol 117: 63-96
7. Couly G (1980) Structure fonctionnelle du condyle mandibulaire humain en croissance. Rev Stomatol Chir Maxillofac 81: 152-163
8. Debry G (1969) Habitudes alimentaires et risques de carence chez le vieillard. Rev Fr Gerontol 15: 393-399
9. Delachapelle C, Laude M, Thilloy G (1981) Etude céphalométrique tridimensionnelle des unités structurales de la mandibule humaine. Bull GIRSO 24: 171-174
10. Delaire J (1978) Analyse architecturale et structurale crânio-faciale. Rev Stomatol 79: 1-33
11. Delaire J (1980) Essai d'interprétation des principaux mécanismes liant la statique à la morphogénèse céphalique. Déductions cliniques. Act Odontol Stomatol 130: 189-220
12. Dhem A (1973) Les mécanismes de destruction du tissu osseux. Acta Orthop Belg 39: 423-443
13. Dhem A (1980) Etude histologique et microradiographique des manifestations biologiques propres au tissu osseux compact. Bull Acad Med Belg 135: 368-381
14. Dhem A, Robert V (1986) Morphology of bone tissue aging. Current concepts of bone fragility. Springer, Berlin Heidelberg New York
15. Doyle F, Brown J, Lachance C (1970) Relation between bone mass and muscle weight Lancet 1: 391 -395
16. Dunn GF, Green LJ, Cunat JJ (1973) Relationships between variation of mandibular morphology and variation of nasopharyngeal airway size monozygotic twins. Angle Ortho 43: 129-135
17. Enlow DH (1966) A morphogenetic analysis of facial growth. Am J Orthod 52: 283-299
18. Finch CE, Hayflick L (1977) Handbook of the biology of ageing. Van Nostand and Reinbold, New York
19. Gandet J (1968) Généralités sur la croissance faciale. Rev Orthod Dent Fac 2: 6-16
20. Garns M, Rohmann CG, Wagner B (1967) Continuing bone growth throughout life: a general phenomenon. Am J Physic Anthrop 26: 313-317
21. Gordon GS, Genant HK (1985) The aging skeleton. Clin Geriatric Med 1: 95-118
22. Goret-Nicaise M (1981) Influence des insertions des muscles masticateurs sur la structure mandibulaire du nouveau-né. Bull Assoc Anat 65: 287-296
23. Goudaert M (1983) La manducation chez les personnes vieillissantes. Bull GIRSO 22: 14-19
24. Jowsey J (1960) Age changes in human bone. Clin Orthop 17: 210-218
25. Koskinen L (1977) Changes after unilateral masticatory muscle resection in rats. A microscopic study. Proceedings of the Finisch Dental Society 73 [Suppl 10-11] : 1-80
26. Laude M (1977) La croissance de la face; le point de vue de l'anatomiste. Rev Belg Med Dent 3: 293-301
27. Laude M, Doual-Bisser A, Thilloy G, Doual JM, Delachapelle C (1984) Approche des relations entre la morphologie musculaire et la morphologie osseuse. Bull GIRSO 27: 80-81
28. Laude M, Doual JM, Doual-Bisser A (1985) Modifications morphologiques du squelette cervico-céphalique en fonction de l'âge. Etude radio-céphalométrique. Bull GIRSO 28: 27-45
29. Laude M, Doual JM, Doual-Bisser A (1987) Massif facial supérieur et sénescence. Bull GIRSO 30: 155-165
30. Linder-Aronson S (1970) Effects of adenoïds on airflow, facial skeleton and dentition. Acta Otolaryngol Suppl (Stockh) 265: 1-132
31. Moller E (1966) The chewing apparatus. An electromyographic study of the muscles of mastication and its correlations to facial morphology. Acta Physiol Scand 69 [Suppl 280] : 1-229
32. Moss ML (1960) A functional approach to craniology. Am J Phys Anthrop 18: 281-292
33. Moss ML (1969) Functional matrices in facial growth. Am J Orthod 55: 556-578
34. Quinn GW (1978) Airway interterence and its effects upon the growth and development of the face, jaws, dentition and associated parts. The portal of life. NC Dent J 61: 28-31
35. Rancurel G (1979) Altération de la neurotransmission et sénescence. Rev Geriatr 4: 7-9
36. Rubinstein J (1977) Étude de la musculature faciale chez l'homme âgé. J Biol Bucc 5: 3-21
37. Stricker M, Raphael B (1993) Croissance crânio-faciale normale et pathologique: l'interception thérapeutique et son devenir. Morfos, Reims
38. Talmant J (1975) Croissance et statique crânio-faciale. Rev Belg Med Dent 30: 267-278
39. Thilloy G (1978) Introduction à l'analyse crânio-mandibulaire. Contribution à l'étude de la dysharmonie crânio-mandibulaire. Orth Fr 49: 7-211
40. Vague J (1983) Hormones et sénescence. Sem Hop 59: 77-85
41. Van Besien Y, Van Besien L (1985) Etude électromyographique globale du système labial chez l'Homme. Motricité comparée du système labial supérieur et inférieur. Influence sur la morphologie faciale? Bull GIRSO 27: 301-305
42. Woodard HA (1964) The composition of human cortical bone. Effect of age and some abnormalities Clin Orthop 37: 187-193

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