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A STUDY OF THE ABNORMALITIES OF THE SKULL, TEETH AND LENSES IN MONGOLISM

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INTRODUCTION

MONGOLISM, which represents about 5% to 10% of all cases of mental deficiency, is a disease entity in which the defect in mental development is associated in a unique way with a large number of physical defects.[26] These are found in many parts of the body, although some are more strongly associated with mongolism than others. It is appropriate, therefore, to distinguish those lesions which are found in other aments, and even in normal people, from those which are characteristic of mongolism because of their distinct nature and because of their frequent occurrence. These stigmata form the basis of the diagnosis of mongolism and they include the peculiar shape of the cranium, the dysplastic features with slanting palpebral fissures and epicanthic folds, the depressed nasal bridge, the dwarfed stature, the characteristic appearance of the brain and cerebellum[9, 10, 18, 19] and the condition of the skin[27] with particular regard to the fine dermal ridges.[11, 35]

Numerous observations have been made since Langdon Down gave his classical description of the mongolian imbecile in 1866 and, although a large amount of information has accumulated since that time, the etiology of the basic disease and the pathogenesis of the associated physical defects are matters of controversy.[3, 15, 31, 36] Many etiological factors have been suggested: a hereditary influence, an inferiority of the germ plasm and various prenatal environmental agents, but so far no conclusive evidence has been obtained of the true nature of the factors responsible for the condition.

In previous papers data have been presented on the occurrence of congenital changes in the skull and teeth[44, 45] and eyes[43] in three series of mongolian imbeciles. Since then additional information on these features has been collected which suggests that a consideration of their pathogenetic interrelationship may be opportune at this time. Furthermore, a study of these changes may afford a more complete picture of some of the physical defects which arise in the sequence of the disease, with particular regard to the uniformity of the findings.

FINDINGS

This investigation is concerned with an examination of the skull, teeth and lenses of a series of mongolian patients of both sexes, who were patients at Leavesden Hospital, Herts., England, and whose ages ranged from 8 to 49 years.

The skull was examined radiographically in 29 patients by posteroanterior and lateral projections as routine procedures, and other views were also taken in special circumstances. Many of these skulls show multiple lesions, making it impossible to classify the changes under one heading only.

Cranium

Variations of shape and texture were present. The brachycephalic skull, often considered particularly common in mongolism,[40] was seen in 14 of our cases. An equal number showed the cribriform plate in an abnormally low position. This structure, which unites the laterally placed labyrinths and encloses the ethmoid notch of the frontal bone, can be quite clearly seen in the posteroanterior view. This feature, in association with the high arched palate and the shortening of the nasal septum, accounts for a considerable narrowing of the nasal space.

A fact to be noted is the widening of the interorbital distance, which was present in 15 of our cases. In this connection it may be worth while mentioning one of the features which Benda[3] described as typical in the radiography of the mongol. In the posteroanterior view the supraorbital border follows an upward curve towards its external border and thus forms a sharp angle with the zygomatic process. The supraorbital notch in mongols is, therefore, not the highest point of the orbital margin, as opposed to the normal adult in whom the supraorbital border curves downwards and articulates at its lateral end with the frontal process of the zygomatic bone, describing a semi-

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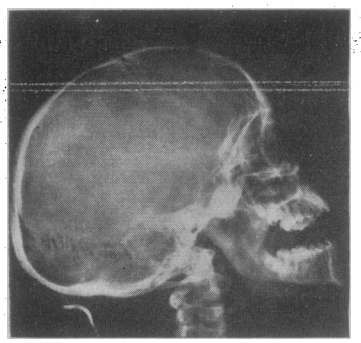

Fig. 1

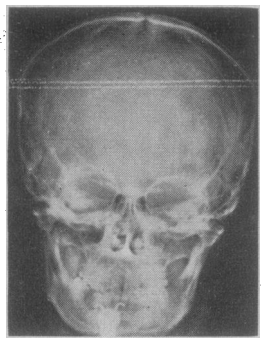

Fig. 2

Fig. 1.—Ronald G., aged 16 years. Note thin skull and absent frontal sinuses. **Fig. 2.**—Jean H., aged 17 years. Note thin skull and small facial skeleton.

circular curve. This abnormal condition was found in 16 cases of this series, but it is difficult to accept it as a typical feature of mongolism because a fair degree of distortion is possible in these cases owing to an error of projection, and owing to the position of the central ray not being comparable in different examinations or in different subjects so that a certain degree of alteration in the shape of the supraorbital border is found when different central rays are used.

For the same reason we have not been entirely satisfied in regarding a radiograph of an egg-shaped orbit as typical of mongolism, because the same error of distortion is possible with different observers using different projections.

The posterior surface of the body of the sphenoid bone which is continuous with the posterior surface of the dorsum sellae, anatomically known as the clivus, normally passes downwards to become lost in the shadow cast by the skull. In the mongolian skull the angle thus produced is rather steep, as was noted in 19 of our cases.

A point which has received little previous attention is the extreme thinness of the skull bones. In this series all cases, with the exception of 2 cases, showed a definite narrowing of the cranial bone tissue (Figs. 1 and 2).

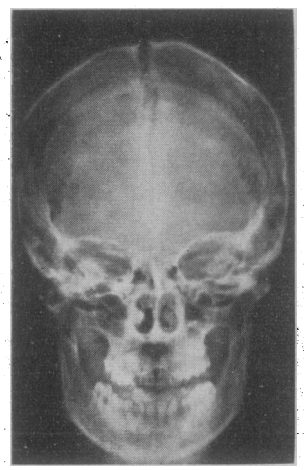

Fig. 3

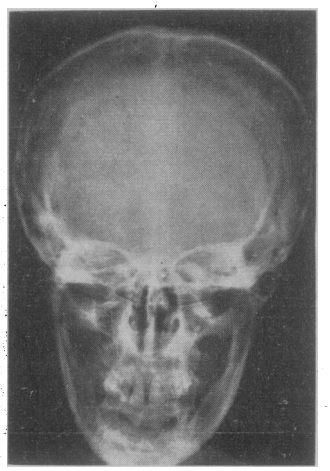

Fig. 4

Fig. 3.—Gladys B., aged 23 years. Note metopic suture; widening of the other sutures; absence of frontal sinuses; small antra and small maxilla. **Fig. 4.**—Rosetta F., aged 23 years. Note wormian bones, absence of frontal sinuses, small maxilla and small antra.

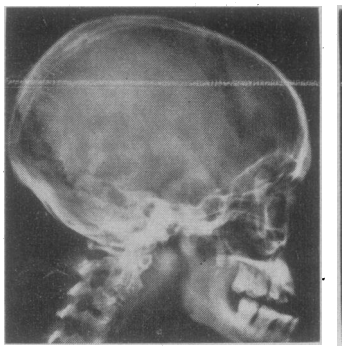

Fig. 5

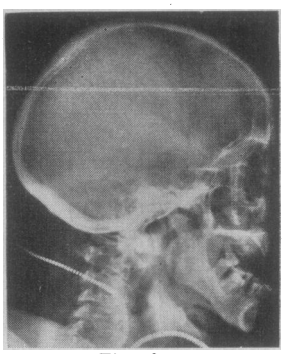

Fig. 6

Fig. 5.—Pauline L., aged 27 years. Note widening of the suture lines, absence of frontal sinuses and thin atlas. **Fig. 6.**—Evelyn G., aged 43 years. Note small maxilla; small facial skeleton; absence of frontal sinuses; forward displacement of atlanto-occipital joint; very thin atlas bone and small anteriorly placed sphenoid sinus.

A number of skulls showed additional foramina and multiple venous channels and calcification in the falx cerebri. Significant too is the presence of a persistent metopic suture in one-third of our cases, which is far in excess of its normal occurrence.[34, 46] Widening of the other suture lines associated with the formation of wormian bones was also noted; the fontanelles, however, were closed in all but two cases (Figs. 3 and 4).

Another skeletal disorder is the forward displacement of the atlanto-occipital joint noted in nine of our cases and the abnormally thin and small shape of the atlas vertebra (Figs. 5 and 6).

Facial Skeleton

The radiographs show various skeletal abnormalities and defects. Predominant among these is the hypoplasia of the middle segment of the face

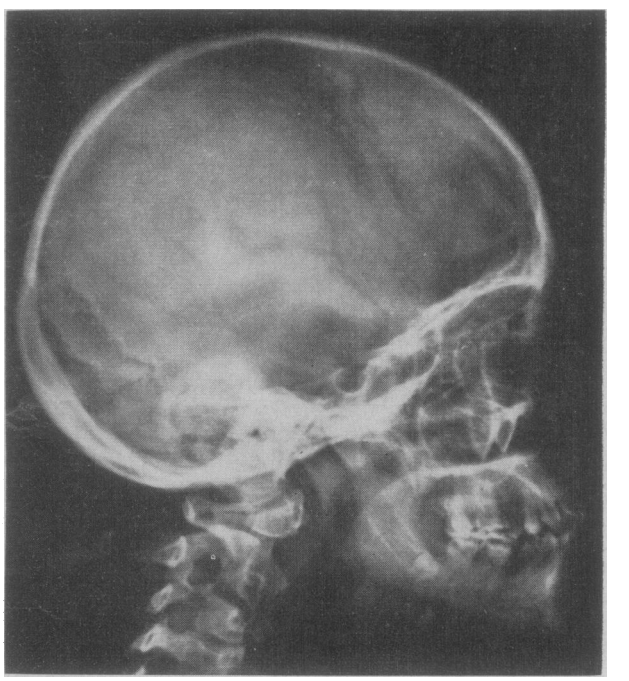

Fig. 7.—Sylvia B., aged 17 years. Note small maxilla, high palate, poorly pneumatized sphenoidal sinuses, absence of frontal sinuses, sclerotic mastoids, and poorly developed teeth.

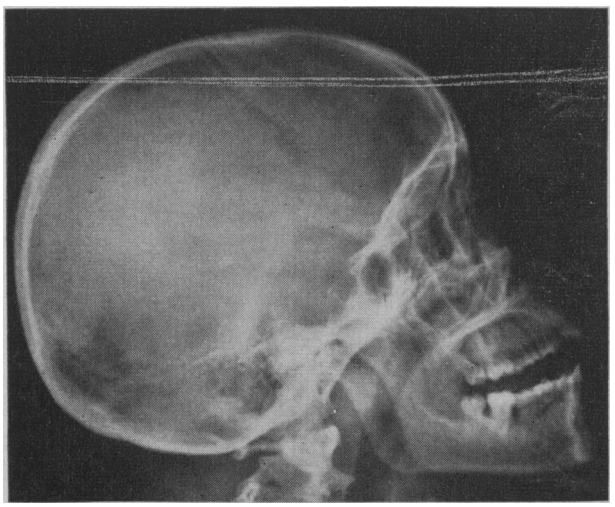

Fig. 8.—Jean H., aged 17 years. Note small facial skeleton; small permanent teeth showing reduced radio-opacity of the enamel; absence of frontal sinuses; poorly pneumatized sphenoidal sinuses, and thin atlas.

involving the maxilla and nasal bones. The diminutive maxilla remains retracted under the protruding forehead, an obvious change of the normal skeletal pattern possibly due to lack of forward and downward thrust during growth. In these instances the distance from the inferior orbital margin to the alveolar crest is abnormally short. The maxillary hypoplasia and the reduced height of the alveolar bone itself are features which accentuate the fetal proportions of the facial architecture in these cases (Fig. 7; see also Figs. 2 and 6).

Paranasal Sinuses

Another important sign is provided by the impaired development of the paranasal sinuses and mastoid air cells. Conspicuous among these disorders is the failure of development of the frontal sinuses which was noted in 24 of the 29 cases which were radiologically examined (Figs. 1 to 7).

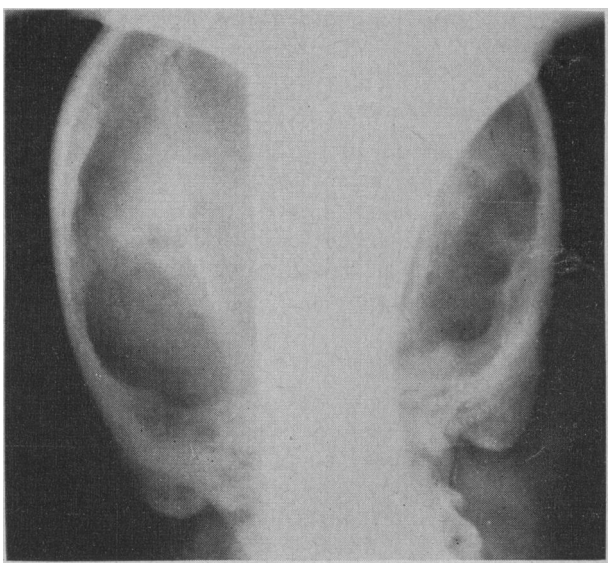

Fig. 9.—Mary V., aged 23 years. Note sclerotic mastoids.

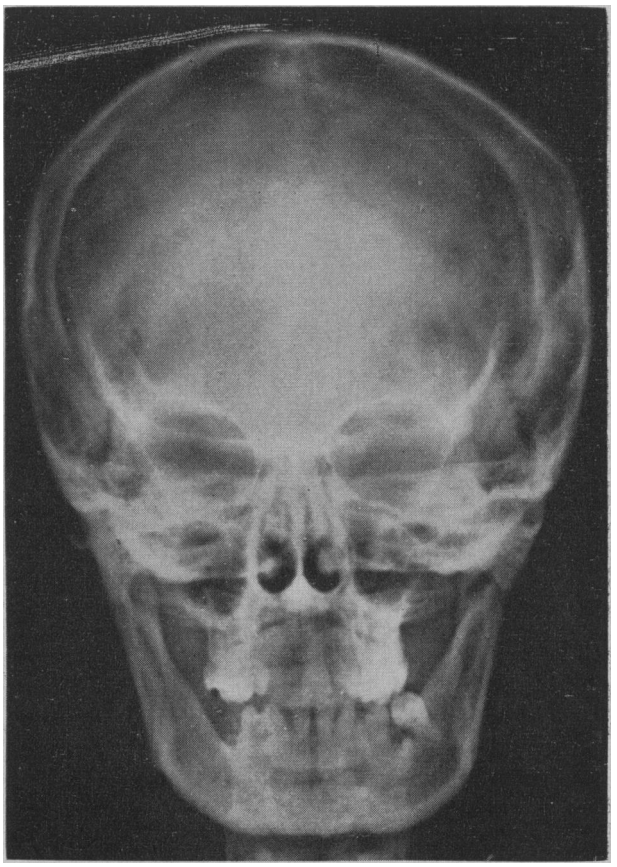

Fig. 10.—Margaret W., aged 21 years. Note absence of frontal sinuses; small facial skeleton; high-arched palate; and reduced radio-opacity of the dental enamel.

Remarkable too are the smallness of the maxillary antra and the poor pneumatization of the ethmoidal and sphenoidal sinuses. In about two-thirds of our cases the sphenoidal sinuses were considerably reduced in size and confined to the anterior part of the sphenoid bone (Fig. 8; see also Fig. 6).

Often co-existing with these changes were poorly developed or sclerotic mastoid cells (Fig. 9).

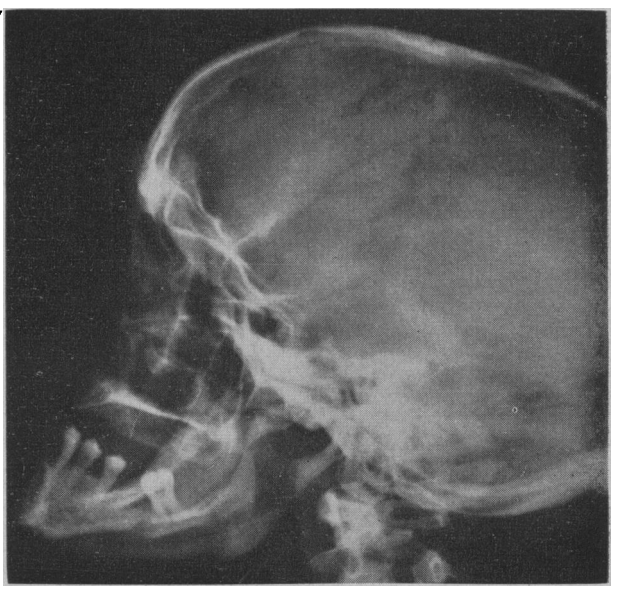

Fig. 11.—William G., aged 35 years. Note obtuse mandibular angle; slender ascending rami; absence of frontal sinuses; small facial skeleton; thin skull; thin atlas.

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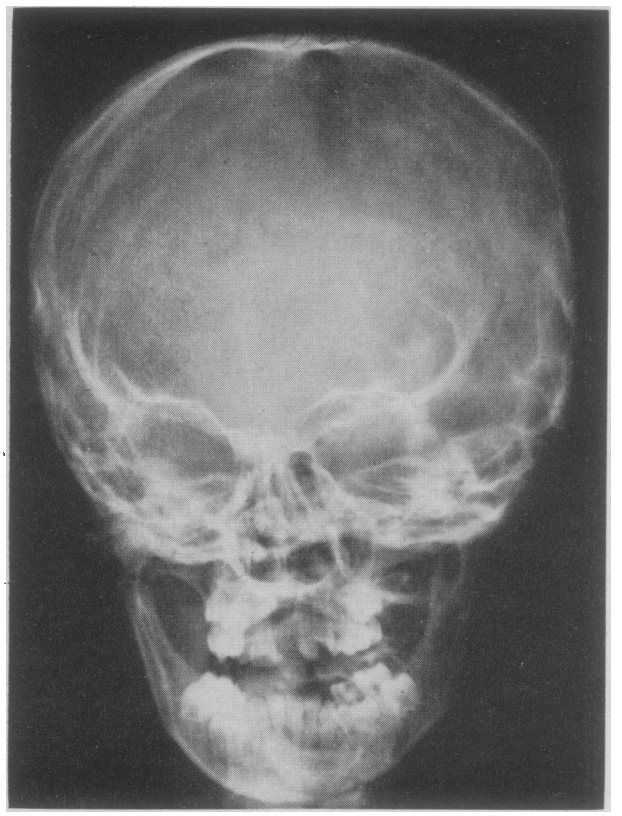

Fig. 12.—Penelope B., aged 10 years. Note small facial skeleton, malformed teeth, microdontism and reduced radio-opacity of the enamel.

Jaws

Both jaws were deficient in anteroposterior, lateral and vertical dimensions. In the majority of cases a high-arched palate, noted clinically, could also be seen in the films (Fig. 10).

The mandible too reflects an abnormality of development. Both the horizontal and the ascending rami tend to be slender and the angle is often obtuse (Fig. 11).

The reduction in size of the oral structures thus contributes materially to the dwarfing of the face.

Dentition

The dental condition presents another facet of the growth deficiency. The teeth show anomalies both in their components and in their dimensions. They are stunted (microdontic) and their crowns are often malformed (formes frustes). Both the maxillary and the mandibular teeth are bilaterally and equally affected. Allied to this there is often aplasia of the enamel which is conspicuous in the radiographs by its reduced radio-opacity. These phenomena have been previously described in detail.[44]

In the present series the incidence of dental lesions was again consistently high. Twenty-nine patients (86%) of a total of 33 patients, who were also ophthalmologically examined, exhibited dental changes of varying degree of structure and/or shape. The different groups of teeth are involved in a similar fashion. The most common and conspicuous manifestations are microdontia and the anomalies of shape (Fig. 12; also Figs. 2 and 10).

Tongue

The tongue often protrudes, not because of an absolute increase in size but as a result of the micrognathia which narrows the floor of the mouth and restricts the available tongue space to an undue degree.

Lenses

Thirty-three patients, 16 males and 17 females, with established mongolism were examined with a view to making a detailed assessment of the state of their lenses. The ages of the patients ranged from 8 to 44 years, the average age being 26. In all cases both eyes were present and were free from any obvious pathological change other than the stigmata characteristic of mongolism. This report is concerned with the lenses of 66 eyes.

Each lens was examined under mydriasis by the following two methods. In the first place, a general assessment of the structure of the lens was obtained by the use of a monocular loupe (× 10 magnification) with direct illumination from a conventional ophthalmoscope. In the second place, a more detailed assessment of any opacities within the lens was obtained with a slit-lamp microscope (× 15 magnification). This involved the use of direct (or focal) illumination in order to obtain a clear view of the main opacities within the lens, but it also included an examination with indirect (or oblique) illumination in order to appreciate the presence of fine lens opacities which would be "drowned" by direct light. All patients were examined by these techniques. The forms of cataract which were found in this examination may be grouped into three main types: arcuate opacities, sutural opacities, and dot or flake opacities. In some eyes more than one type of opacity was present, and there were only two patients in the series with clear lenses.

1. *Arcuate Opacities*

Arcuate opacities were found in 10 (or 31%) of the patients, and in 15 (or 23%) of the eyes. In each case the arcuate opacity lay deeply within a localized sector of the lens in the region of the fetal nucleus and it arched round the equator in an anteroposterior direction.

2. *Sutural Opacities*

Fine punctate opacities were present in the Y sutures, which represent the sutures of the fetal nucleus, in 20 (or 61%) of the patients and in 40 (or 61%) of the eyes. In six eyes the sutural cataracts were present to an equal extent in the anterior and posterior Y sutures, but in six eyes they were slightly more marked in the anterior Y sutures and

in eight eyes they were slightly more marked in the posterior Y sutures. In all cases the sutural opacities were present in both eyes. There was also involvement of the sutures of the adult nucleus in one case, but in all other eyes the sutural opacities were confined to the Y sutures only.

3. *Dot and Flake Opacities*

Fine dot and flake opacities were present in the outer nuclear layers (infantile and adult layers) in 28 (or 85%) of the patients and 56 (or 85%) of the eyes. In addition to the opacities in the outer nuclear layers, one eye showed dot opacities in the cortex of the lens, one eye showed flake opacities in the fetal nucleus, and one eye showed fine opacities in the embryonic nucleus (cataracta centralis pulverulenta).

The other five patients showed no evidence of any dot or flake opacities except for one patient who had dot opacities confined exclusively to the outer cortex.

DISCUSSION

The structural abnormalities seen in these cases suggest a prenatal growth failure. Theoretically there is a large number of etiological causes to be considered in relation to such an event. One has to remember that a range of environmental teratological situations occurring at a critical period of gestation and organodifferentiation will invoke developmental interference.[13, 17, 22, 39, 48] It has further to be stressed that manifestations of disordered growth as seen in this series are also compatible with inherent weakness of the anlage which affects its ability to achieve complete development, and as a result of this, irreparable changes are bound to occur in many derivatives. So far, however, there is no precise knowledge of all these basic factors involved in the process.

The facial dysplasia, the classical feature of the mongolian syndrome, reflects a fault in the chondrocranium which is the essential element for facial growth.[4, 5, 16, 41]

Developmental considerations also provide the explanation for the failure of paranasal sinus development.

The growth potentialities of the air sinuses are vested in the primordial nasal epithelium from which they derive.[25] All sinuses, with the exception of the sphenoidal sinus which appears after birth, start to form during the fourth or early part of the fifth month of fetal life. The absence of the frontal sinuses which is noted more often in association with mongolism than with any other syndrome is apparently of no minor influence on the characteristic shaping of the frontal bones and forehead. There is also a definite tendency to deficient pneumatization of the other air chambers and of the mastoids. The frequency of these affections raises the question of whether such a widespread involvement is determined causally. It is difficult to see how the multiplicity and frequency of these particular defects predominantly occurring in mongolism are able to be induced by environmental agents only. The answer seems to be that these disorders arise in response to the action of a specific endogenous factor or to a set of such factors. A point of interest is raised by Caffey,[8] on the condition of the mastoids in Cooley's disease which are characterized by a lack of mastoidal pneumatization as shown radiographically. This represents another phenomenon showing a hereditary fault which is associated with the growth defect of the tympanic bone.

The mandibular changes can be attributed to deficient condylar development which is epiphyseal in character.[12] In consequence there is a lack of downward growth relative to the condylar fossa. These changes and the poor appositional growth at the other growth centres are the factors which contribute materially to the short and slender rami.

The study of the dental changes brings to light another aspect of a prenatal growth disorder. Both the anomalies of shape (stunting) and the structural lesions (enamel hypoplasia) are conditions which are compatible with such an etiology. Although the teeth are intimately connected with the osseous system, they are essentially dependent for their development on ectodermal maturation, and damage to the dental primordiae results in irreversible changes. This concept is supported by numerous observations on various gene-determined systemic conditions in which the dental changes are part of the syndrome.[2, 6, 14, 32, 38, 42]

Grueneberg,[20] who investigated the interaction between the endogenous and exogenous factors in bone and tooth development, states that the shape of the tooth socket and ultimately that of the alveolar bone depends upon the growth tendencies of the tooth germ.

An assessment of the changes which are found in the lenses in mongolism reveals three significant findings. Firstly, the arcuate type of opacity is found in about one-third of the cases, whereas it is a rare finding in the rest of the population even when the lens is involved in some other pathological process. It is of great interest that in mongolism the arcuate opacity is isolated within the lens, and this may indicate that the factor which favours the development of the opacity is a temporary phenomenon. It is suggested by Lowe[30] that the arcuate lens opacity represents a patch of lens fibres which become opaque. This is in contrast to the other lens opacities of mongolism which represent opaque deposits between the lens fibres. The arcuate opacity may be induced by the presence of an abnormal capsulo-pupillary vessel at an early stage of fetal life, and this may be an indication of an early disturbance of the vasoformative tissue in the development of the mongol. Secondly, the opacification of the Y sutures is found in nearly two-thirds of cases, whereas it is not a common finding

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in the rest of the population. Thirdly, the dot and flake types of opacity were found in more than four-fifths of cases, but no special significance should be attached to this figure because it is known that such opacities, particularly the dot variety, are practically a normal feature of any lens. It is interesting, however, that in mongolism the dot and flake opacities tend on the whole to be more abundant and also to be more deeply placed in the nucleus than similar opacities of normal eyes which are usually confined to the outer nuclear and inner cortical layers. It would appear that the process which determines the presence of such opacities exerts its influence at an earlier stage and with a greater intensity in mongolism than in the normal population. Indeed, it is likely that the presence of Y sutural cataract in mongols is an expression of a similar early event because there is evidence that the punctate sutural opacities correspond in structure to the dot opacities of the nucleus and cortex.

CONCLUSION

The information gained from this study reveals that the anomalies do not occur sporadically but form a pattern of defects. This emphasizes the impression that the etiological mechanism is one of a basic nature linked with the systemic pathogenesis which in its ultimate stage will result in mongolism.

The anatomical defects involving a large range of tissues of different derivation show a high degree of clinical and radiological uniformity in the way their normal course of development has been deflected. These facts must weigh against a chance incidence and also appear to question the overall importance of prenatally acquired factors.

Consideration of the data suggests that the anomalies have been impressed on the developing fetus by genetic endowment. This is the agent which by its mechanism and quality is able to control the reaction to norm initially. The inference that these lesions are precipitated in this way seems, therefore, not to be without justification. It can be assumed from the observations by Penrose[36, 37] and Allen[1] on the increased incidence of mongoloid traits in the near relatives of the "mongol" that a hereditary element in the etiology of mongolism is more than a possibility.

The significance of the genetic aspect in the causation has previously been stressed by Mayer-Gross *et al.*,[31] Jervis[24] and other authors,[37, 47] and the investigations on the chromosome anomaly in mongolism[23, 29] also weigh decidedly in favour of this argument. Thus, although adverse harmful prenatal influences may have a definite place in the causation of the characteristics, the outcome will be decided by the genetic potential upon which they act.

SUMMARY

A report is made of the developmental disorders in skull, eyes and teeth in a series of mongoloid imbeciles who were patients at Leavesden Hospital, Watford, Hertfordshire, England.

The clinical and radiological appearances of these lesions are described and discussed. The anomalies are of an order to suggest a prenatal developmental interference.

Although the actual mode of action remains unexplained, the observed facts are suggestive of an inherent fault in the anlage as the determining agent in the pathogenesis of these changes.

We wish to acknowledge our indebtedness to Dr. E. F. Hewlitt for his co-operation with this investigation and for permission to make use of the hospital records and facilities. Our thanks are also due the nursing staff for their help, and Mr. Beadle and Mr. Chamberlain, the hospital radiographers, who took all the radiographs.

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