Age determination.—Only a beginning has been made in the assessment of age from the dentition. Much more research is required.

Bite marks.—Bite marks on human skin and in inanimate materials present quite different problems. Research should be carried out on the way human skin changes after a bite. The deformations must obviously follow a certain pattern depending on the structures of the tissues and here only a close co-operation between the forensic pathologist and the dentist can give good results.

In bite marks on human skin every tooth cannot be expected to give a definite mark. Only those parts of the teeth which come into contact can be recognized and lateral movements during biting are very common. Therefore it is essential to make impressions of the teeth and to place them into an articulator which enables the teeth to be moved into contact with each other. It is perhaps unnecessary to say that those who deal with human bite marks must be very familiar with bite habits and with the articulation of teeth. Furthermore, since we are all influenced to some extent by what we expect to find I would say that it is advisable when investigating bite marks that two dentists should co-operate, one doing the description of the bite marks and the other the description of the teeth of the suspect, before they are allowed to make comparisons. Bite marks in inanimate materials are in a way much more informative and easier to deal with.

Time lapse since death.—The teeth of individuals who have been in water for a certain time change colour and become red-brown. It does not appear to be known how long it takes for these colour changes to occur and it would seem possible that some good would derive from a study of this phenomenon.

Training of the dentist.—There is an undoubted need for training a limited number of dentists in this special field, both in its scientific and practical aspects. These would form a nucleus for expansion in time of war. It is essential also that a course in forensic dentistry should form part of the basic undergraduate curriculum.

The identification of the victims from big disasters, particularly fire accidents like the burning of the steamship *Noronic*, needs planning and team work. It is very uncertain whether at short notice enough dentists could be found willing to deal with 400 or 500 badly burned bodies, where only partial remains are available and where recognition by superficial examination is usually out of the question.

There is undoubtedly a need for an accident commission in which medical examiners, police departments and dentists co-operate. It would be advisable to have two dentists working, one in the field investigating the remains and one at home collecting and comparing the investigation with data from dental records.

It is evident that there is growing awareness of the value of dental identification but it is also clear that dentistry cannot fulfil the requirements unless training, research and teaching receives more support from the authorities.

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The Assessment of Age from the Dentition

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AGE assessment is one of the most important problems of forensic odontology. It may for example be necessary to try to assess age from a single isolated tooth. During the period of tooth development up to about the age of 20 years it is possible to assess age from the teeth and jaws with a moderately high degree of accuracy, up to the age of 14 years probably with an error of little more than one year. Between 14 and 20 years the accuracy diminishes progressively as more and more reliance has to be placed on one tooth only, namely the third molar which appears to be more variable in its time of development than other teeth.

For the assessment of age during the period of tooth development recourse is made to tables of the chronology of tooth development, the diagrammatic one prepared by Schour and Massler (1941) being the most commonly used. In order to ensure that the data given in this table hold good for English children and to test the accuracy with which age could be assessed by it, the ages of 58 children were estimated from lateral jaw radiographs of the cheek teeth, solely with the aid of the table. Fig. 1 sets out for comparison the real and estimated ages. Up to the age of about 12 years most estimates fall near the real age, few being more than a year out. Over the age of 12 years, however, there is an increasing amount of scatter and many are two years or more above or below the line. Although the

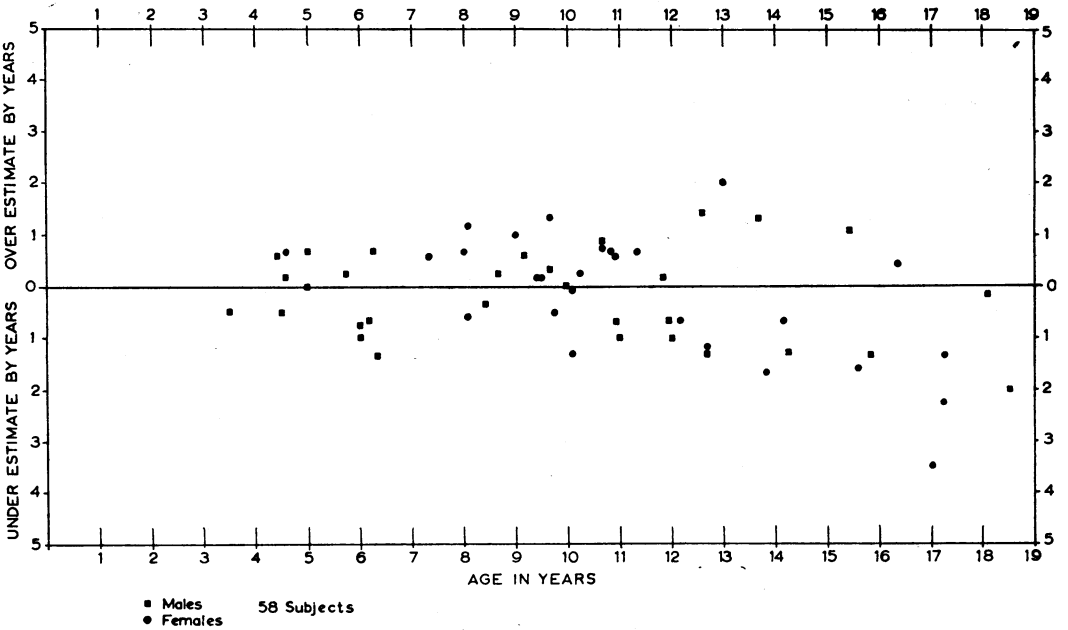

FIG. 1.—Estimates of ages from lateral jaw radiographs of the mandibles of 58 children, using table of chronology of tooth development of Schour and Massler (1941). The horizontal line represents the real ages.

sample is too small for any definite conclusions to be drawn, the fact that the estimates fall about equally above and below the line suggests that the table of Schour and Massler is accurate for English children but that certainly in later childhood there is a considerable range of variation in the chronology of tooth development. It may be significant that the estimates tend to fall consistently too low over the age of 16 years and it is possible that the table needs some correction for the chronology of development of the third molars.

Clements and his colleagues (1953) have provided extremely useful data on the chronology of clinical tooth eruption in English children as opposed to tooth development studied radiographically. The exhaustive study of the chronology of development of the permanent mandibular first molar in American children published by Gleiser and Hunt (1955) is a model of its kind and if extended to other parts of the dentition would be of enormous value for forensic purposes. The collection of corresponding data on English children would be advisable in case racial and environmental factors influence the timing of tooth development more than is suggested by my own very limited investigation.

As an illustration of age assessment during the early phase of tooth development it is appropriate to recount an experience in respect of the mummified remains of an infant found in a trunk. Figs. 2 and 3 show radiographs of the mandible. The symphysis showed signs of commencing closure and tooth development was a little more advanced than at birth; for example, two cusps of the first permanent molar were formed (Fig. 3B). The age was therefore estimated to be 3 or 4 months of post-natal life. Some time later a longitudinal ground section of one of the first molars was prepared and a prominent incremental line in the position of a neonatal line was found in both the enamel and dentine. By measuring the thickness of dentine on the pulp side of this line confirmatory evidence was obtained that our age determination was correct. Massler and Schour (1946) have shown that deciduous dentine is laid down at the approximate rate of 4 μ per day. The thickness of dentine in the present case was 312 μ giving an estimate of 3 months and 9 days, allowing 15 days for neonatal arrest of dentine growth.

After the completion of tooth development it becomes increasingly difficult to assess age accurately. This is illustrated by the results of age estimations recently made on 47 skulls of the early part of the last century from a burial ground in the City of London. The real ages were known from data on the coffins but were, of course, unknown to me at the time the estimations were made. In making the estimations account was taken of the teeth and jaws only and other features, such as cranial sutures, were ignored. The results are depicted in Fig. 4. Where the vertical lines cross the circles the real age came within the estimated range and in the three instances where the mid-points of the vertical

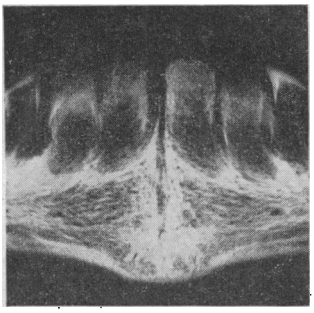

FIG. 2.—Radiograph of mandible of the unknown infant. The lower part of the symphysis is united.

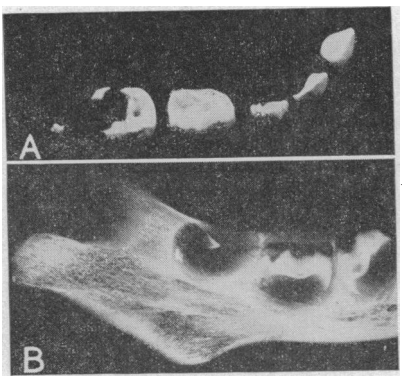

FIG. 3.

FIG. 3.—A, Formed parts of teeth from mandible of newborn infant. The cusps of the second deciduous molar are not fused to form a complete occlusal surface and the tip of one cusp only of the first permanent molar is formed. B, Radiograph of mandible of the unknown infant. Two cusps of the first permanent molar are present.

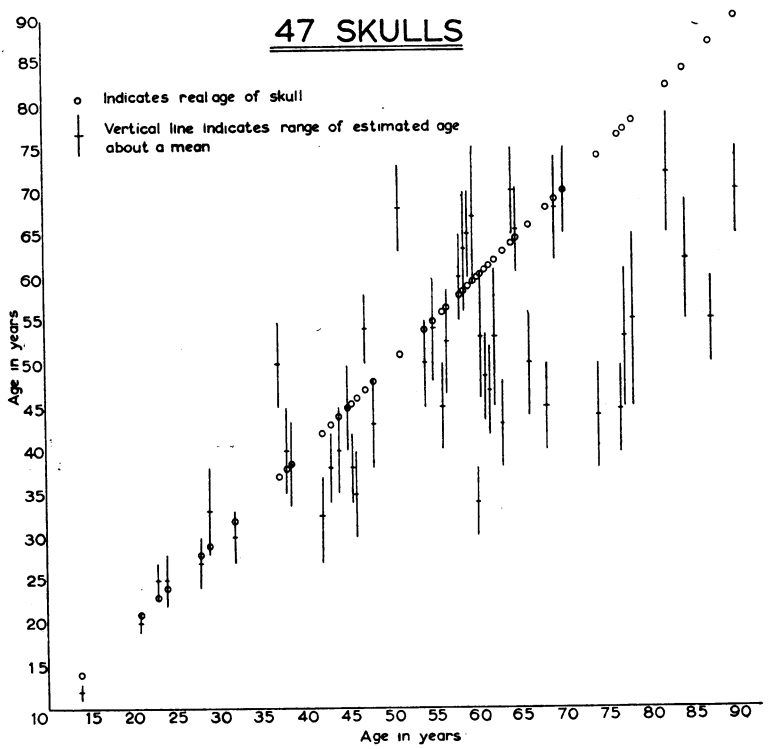

FIG. 4.—Estimates of age of 47 skulls from the jaws and teeth.

lines fall on the circles the estimated age corresponded exactly with the real age. The group below the age of 35 years shows a fairly close score but there is a good deal of scatter between the ages of 40 and 70 years. It is of interest that all the estimations for skulls over the age of 70 years fall well below the real ages. This is no doubt due at least in part to a tendency to discount the chance of there being in any collection of skulls any from persons who have survived beyond the usual span of life.

In mitigation of this rather poor performance it should be noted that no evidence was obtained from radiographs, the degree of closure of cranial sutures, which is admittedly unreliable, or other cranial features.

The age estimations were made by what may be called the intuitive method; that is, by a subjective evaluation of a number of factors, some not easily defined, but which were

principally attrition, the condition of the supporting tissues of the teeth and, where it was possible to remove teeth from their sockets, the thickness of the cementum. Gustafson (1950) has evolved a method which is much more scientific and which at least in his hands would undoubtedly have given a better result. His method makes use of six features which alter with advancing age; attrition, the gingival attachment migrates towards the apex, the size of the pulp cavities diminishes, the translucency of the apex and the thickness of the cementum increase and areas of resorption of the root surfaces increase. With the aid of a longitudinal ground section he allots points to each of these features separately according to degree and finally assesses age by comparing the total points scored with similar data collected from teeth of known age. As no doubt he would agree, the successful use of his method depends upon the observer having a good deal of previous experience. Nevertheless he has made a very substantial contribution to this subject by showing the way to tackle the problem. It is possible that the principle of his method, assigning values independently to as many criteria as possible and then comparing the total values with similar data from material of known age, could with advantage be applied to the degree of closure of cranial sutures.

Scott *et al.* (1949), using replicas of enamel surfaces, found that certain changes in the surface details are consistently related to age. Particularly as these changes appear to be independent of the factors causing occlusal wear (Pedersen and Scott, 1951), they might possibly provide another criterion to be added to the six used by Gustafson. An endeavour to substitute actual measurements for the subjective allocation of points to the criteria might prove fruitful. If this were possible it would enable relatively inexperienced people to make use of data collected by other workers and so help to overcome the difficulty Gustafson has referred to of training people to do this sort of work.

One of the things that makes forensic work so interesting is that it is necessary to examine closely morphological details which otherwise would receive little attention. An example of this which has been reported elsewhere (Miles and Fearnhead, 1953) derives from an attempt to assess the age of a fragmentary maxilla in which the third molar was fully erupted and unmarked by attrition and behind which was a well developed bony tuberosity. It was at first argued that such a tuberosity would not be found until several years after the eruption of the third molar and the age was assessed at about 25 years. The examination of radiographs of a number of subjects aged about 20 years, however, showed that it is quite common for there to be a well developed tuberosity at this age. On this basis and the relatively large size of the pulp cavities in the molars the age estimate was therefore revised to 20 $\pm$ 1 year which proved to be quite close to the otherwise proven real age.

In general the dentition gives very little assistance in the determination of sex and individual teeth have no stigmata of sex at all. The determination of sex from the skeletal remains of sexually immature children is extremely difficult and uncertain, but Hunt and Gleiser (1955) have suggested a method which makes use of the fact that, whereas there is little or no sex difference in the chronology of tooth development, skeletal maturation is about one year earlier in the female than in the male. Hunt and Gleiser determine the age of the skeletal remains from the dentition by using Schour and Massler's tables of tooth development and then the age is determined independently by a study of the maturation pattern of the bones of the hand or some other part of the skeleton making use of data published by Greulich and Pyle (1950). If the dental and bone ages correspond closely the skeleton is probably male and if the bone age is advanced in comparison with the dental age it is probably female. In a blind test of the method Hunt and Gleiser sexed correctly 73% of a sample of 2-year-old children and 81% of 8-year-old children. This technique might well prove of value to those called upon to deal with forensic problems.

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