RADIOGRAPHS OF THE HAND AS AN INDEX OF SKELETAL MATURITY IN INFANTS

BY
ROY M. ACHESON

From the Institute of Social Medicine, Oxford

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We are indebted to the late Professor Wingate Todd (1937) and his colleagues for the concept of skeletal maturation as a specific entity in the growth process. It has long been known that hypothyroidism is a potent cause of retardation in the maturation process. Francis (1939) and other authors in the Brush Foundation group have shown that any infection or feeding difficulty may hold back normal progress towards skeletal maturity. It is the purpose of this paper to review the histories of nine skeletally retarded 1-year-old children seen in the Oxford Child Health Survey.

Material

The children followed in the Survey were born in Oxford between 1944 and 1948 and recruited from municipal infant welfare centres and a private clinic. They were 580 in number, and the social class grouping (Registrar-General, 1911) was as follows:

<table>
<thead>
<tr>
<th>Social Class</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>5.2</td>
</tr>
<tr>
<td>II</td>
<td>10.17</td>
</tr>
<tr>
<td>III</td>
<td>66.8</td>
</tr>
<tr>
<td>IV</td>
<td>10.17</td>
</tr>
<tr>
<td>V</td>
<td>7.59</td>
</tr>
<tr>
<td>Unoccupied</td>
<td>0</td>
</tr>
</tbody>
</table>

Selection of Cases

The osseous centres for capitate and hamate are visible by radiograph in both sexes by 6 months of age (Davies and Parsons, 1927; Paterson, 1929). Modern authors maintain that these bones are radiologically visible in the hand of the average girl at 2 months and the average boy at 3 months (Francis and Werle, 1939; Pyle and Sontag, 1943). It was therefore decided that the absence of either of these bones in either hand at the age of 1 year could be taken as an indication of skeletal immaturity. Of the 580 children in the Survey, an antero-posterior radiograph of each hand was taken in 561. Eight fell into the group defined above as immature. Six were boys, and two were girls. Since girls mature more quickly than boys (Flory, 1936; Pryor 1923) this distribution is to be expected. In addition a girl whose hamates and capitapates were so rudimentary as to be only visible on the closest scrutiny of the x-ray plate has been included. The nine cases will be referred to as the selected group, and the 561 children from whom they were picked as the survey group.

The only routine radiographs other than of the hands, which were taken of all the children, were antero-posterior films of the knees and chests. The chest is, of course, of no help in accurately assessing skeletal age. Although the knees of all the nine selected children were rather more retarded than the mean of the survey group, in one case alone (Case 8) was the retardation really gross. This child was a cretin.

Data

Cretinism. One child (Case 8) was the most backward of the nine, and was found at the age of 1 year to be a cretin. Radiographs gave the lead to the diagnosis, which was substantiated by clinical appearances. Until this time the mother was quite unaware that anything was wrong with her girl, for in spite of frequent visits to the clinic, the diagnosis had not been obvious to the physicians. She yielded immediately to thyroid therapy and at the age of 5 had an intelligence quotient of 100.

Obstetric. All the children were delivered normally. Apart from the minor ante-natal and post-natal complaints listed in Table 2, the mothers had good health. Although the mother in Case 6 had had rheumatic fever as a girl, she had no history of cardiac involvement at any time. Apart from the child in Case 5, who was born at home, and in Case 3, who was born in an institution run by the Oxford City Health Department, all the babies were born in maternity departments of the Oxford hospitals. Birth was three weeks premature in Case 6, and was three weeks after the expected...
date of delivery as calculated by the mother’s last menstrual period in Case 3.

Illnesses. The premature child (Case 6) was detained in the Radcliffe Infirmary, Oxford, for the first month of his life because of physiological jaundice. On his visits at 3 and 6 months of age he was described as a good, contented baby. On his fifth visit, aged 12 months, he was just recovering from a cold and had impaired air entry in both lungs.

One child (Case 1) was said by his mother to have had measles when 2 months old, but it is not certain that there were grounds for this diagnosis. One child (Case 3) had pemphigus neonatorum in the first week of life. However, the complaint quickly yielded to penicillin.

Apart from a setback in her tenth month, when she had tonsillitis with slight diarrhoea, the health in Case 7 was excellent.

Umbilical Hernia. Five of the nine selected children (55%) had umbilical hernias. This is similar to the figure of 53% for the whole survey group.

Milestones. The children all achieved the usual milestones of the first year (Table 3). Some were precocious; Case 9, a girl, was walking at 8 months, and Cases 4 and 5 were repeating words before the age of 12 months.

Teeth. Apart from the cretin only two of the children had no teeth at 1 year. In the rest of the survey group it was found that 6% of the girls and 7% of the boys were edentulous at this age. One of the selected children (Case 5) had 13 teeth. Only 6% of the survey group of boys and 4% of the survey group of girls had this number or more at a year. The other five selected children had four to six teeth at 12 months. This compares favourably with the mean of four to five teeth at this age for the whole survey group.

Fontanelle. Two children (Case 2 and Case 8, the cretin) had fontanellas at 1 year of age unusually widely open for their age. The others fell well within normal limits. In the survey group no correlation has been found between closure of the fontanelle and hand maturity.

I.Q. at 5 Years of Age. Five of the children remained in the survey group until they reached the age of 5. Of these only one, Case 7, had an I.Q. of less than 100 on achieving this age. The Terman-Merrill revision of the Stanford-Binet test, Form L, was used.
ARCHIVES OF DISEASE IN CHILDHOOD

TABLE 3

GENERAL DEVELOPMENT

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Missing Bones in Hand</th>
<th>Head Up</th>
<th>Hear and See</th>
<th>Sit</th>
<th>Crawl.</th>
<th>Stand</th>
<th>Other</th>
<th>No. of Teeth at 1 year</th>
<th>Fontanelle (Fingerbreadths at 1 year)</th>
<th>I.Q. at 5 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Left hamate</td>
<td>No record</td>
<td>12</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
<td>2</td>
<td>108</td>
</tr>
<tr>
<td>2</td>
<td>Right capitate</td>
<td>3</td>
<td>6</td>
<td>5</td>
<td>9</td>
<td></td>
<td>Drinks unaided, 12</td>
<td>3</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Right hamate</td>
<td>3</td>
<td></td>
<td>5</td>
<td></td>
<td>12</td>
<td>12</td>
<td>4</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Both hamates</td>
<td>2</td>
<td>3</td>
<td>9</td>
<td>11</td>
<td></td>
<td>Words, 12</td>
<td>4</td>
<td>Closed</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Right capitate</td>
<td>3</td>
<td></td>
<td>8</td>
<td>22</td>
<td></td>
<td>Words and drinks, 11</td>
<td>13</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Both hamates</td>
<td>No record</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
<td>Closed</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Right hamate</td>
<td>2</td>
<td>3</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td></td>
<td>6</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>All bones</td>
<td>3</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Four very primitive bones only</td>
<td>3</td>
<td>6</td>
<td>8</td>
<td></td>
<td></td>
<td>Walked, 8 Feeds self, 12</td>
<td>6</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

Weight. It will be noted that two of the full term babies (Cases 4 and 7) were very light at birth, each weighing 5 lb. 1 oz. The premature child (Case 6) weighed 6 lb. 1 oz. The average weight of the selected boys was 14 oz. less than the average for all the boys in the survey group. This figure is almost twice its standard error, and indicates a significant difference between the two male averages. Since there are only three girls in the selected group, the standard error of the difference between the selected and general female averages is much larger. Therefore, although the difference observed is the same as it is for the males it is not statistically significant. However, the tendency for the immature girls to be light at birth is clearly seen.

Since the weight range at 1 year is greater than at birth, the differences between the averages at 12 months (20 oz. for males and 19 oz. for females) are too small to be considered significant.

Feeding. Case 1 was the only one which was not breast fed for at least four months. No feeding troubles were experienced by this child or any others. The proportion breast fed (88%) is much higher than the figure of 53·8% for the survey group children who were breast fed for at least four months.

Social Background. The mother's estimate of the amount of money spent per adult per week is included in Table 5. In considering these figures allowances must be made for individual miscalculations, and for the fact that these estimates were made in 1949, before the sharp rise in the cost of living. The mean expenditure in all the homes under survey was 15/6d.; in this small group it is approximately 22/6d.

Seven of the children came from homes of Social Class III (Table 1).

Discussion and Conclusions

Nine children have been described in whom the bones of the hands have been remarkably slow to show evidence of ossification. Since the hand is widely used both in the diagnosis of cretinism and as an indication of general skeletal maturity, an apparent anomaly of a normal developmental process must be considered.

Of these children, with the exception of the
cretin (Case 8), only Case 6 can be considered to show more than a fair share of illnesses. It will be remembered that the child had severe physiological jaundice after birth and remained sickly for some months afterwards.

Three of the children, including the premature infant, were light at birth; thus the correlation found for the survey at large between skeletal immaturity and lightness, both at birth and at a year, seems to be substantiated by this small group.

It has been pointed out that although the ossification centres in the knees of these children were slightly retarded, it was in the cretin alone that the marked backwardness visible in the hand was matched by a comparable retardation in the development of the centres of the knee.

Although much work has yet to be done on the value of the hand as an indicator of skeletal maturity, it seems that the following conclusions may be drawn:—(1) Although it has been shown that illness can delay the appearance of osseous centres in the hand of a young child, an immature hand does not necessarily indicate a sick baby. (2) There is a tendency for light children to mature more slowly than heavy ones. (3) Cretinism should not be diagnosed radiographically from the hand alone.

Summary

The histories of nine 1-year-old children with skeletally retarded hands are described. They are selected from 561 children of similar age seen in the Oxford Child Health Survey. Their social background is considered briefly.

One child was diagnosed as a cretin, two were very light at birth (both 5 lb. 1 oz.) and a fourth, a premature child (birth weight 6 lb. 1 oz.), was in hospital for the first month of life because of physiological jaundice.

The correlation found in the entire survey between skeletal maturation and lightness at birth and at 1 year of age seems to be borne out by these nine children.

The conclusion is drawn that although radiographs of the hand alone have great diagnostic worth in cases of skeletal retardation, they are more valuable when considered in conjunction with radiographs of other parts of the skeleton.

I should like to express my gratitude to Dr. Alice Stewart, Director of the Institute of Social Medicine, and to Dr. F. H. Kemp, of the Radcliffe Infirmary, Oxford, for their advice and assistance in the writing of this paper.

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Radiographs of the Hand as an Index of Skeletal Maturity in Infants
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