Acta Paediatrica Hungarica, 24 (3), pp 221—229 (1983)

Assessment of skeletal age in the first year of life on basis of the caput humeri ossification centres

B LOMBAY

Section of Radiology, County Children's Hospital, Miskolc, Hungary

A new procedure has been worked out to estimate skeletal maturity in infancy. The size of the caput humeri ossification centres was determined with the help of a pattern set from the antero-posterior chest roentgenogram. In each month of the first year of life 100 examinations were carried out and from their data percentile lines were constructed for every month of life.

Determination of skeletal age by means of X-rays is a generally accepted method to evaluate biological maturity. Examination of the appearance, shape and number of ossification centres (OC) may reveal deviations from normal characteristic of certain diseases and sometimes has a role in the evaluation of therapy, for instance in hypothyroidism, adrenogenital syndrome, growth hormone deficiency, etc. Tables for estimation of skeletal age have been compiled by many authors. Most of them dealt with the ossification of the hand and wrist as well as the leg, knee and elbow. These methods are useful for older children, but an accurate evaluation in infancy is hindered by the late appearance of the OC [4]. Elgenmark [2] determined skeletal age from X-rays of the left side of the body with special regard to OC of the foot, leg, femur, hand, forearm and upper arm. Caution is however recommended, especially in the case of control examinations, in view of the radiation exposure. Recently Senecal et al [11] and Erasmie and Ringertz [3] have developed a new method by measuring the OC of the lower limb of newborn babies.

We have attempted to study the OC of the proximal epiphysis of the humerus as it appears on chest X-rays. This OC is mostly present at birth and its development can be easily observed and might be convenient for the determination of skeletal age in infancy. We have therefore elaborated a uniform method for measuring the proximal OC of the humerus and studied its relation to skeletal age.

In the first year of life purely enchondral ossification prevails in the epiphysis of the humerus [7] and two of the three proximal OC appear, the medial and the lateral one. Their radiomorphology has been described by Marique [8]. Depending on birth weight and racial characteristics the

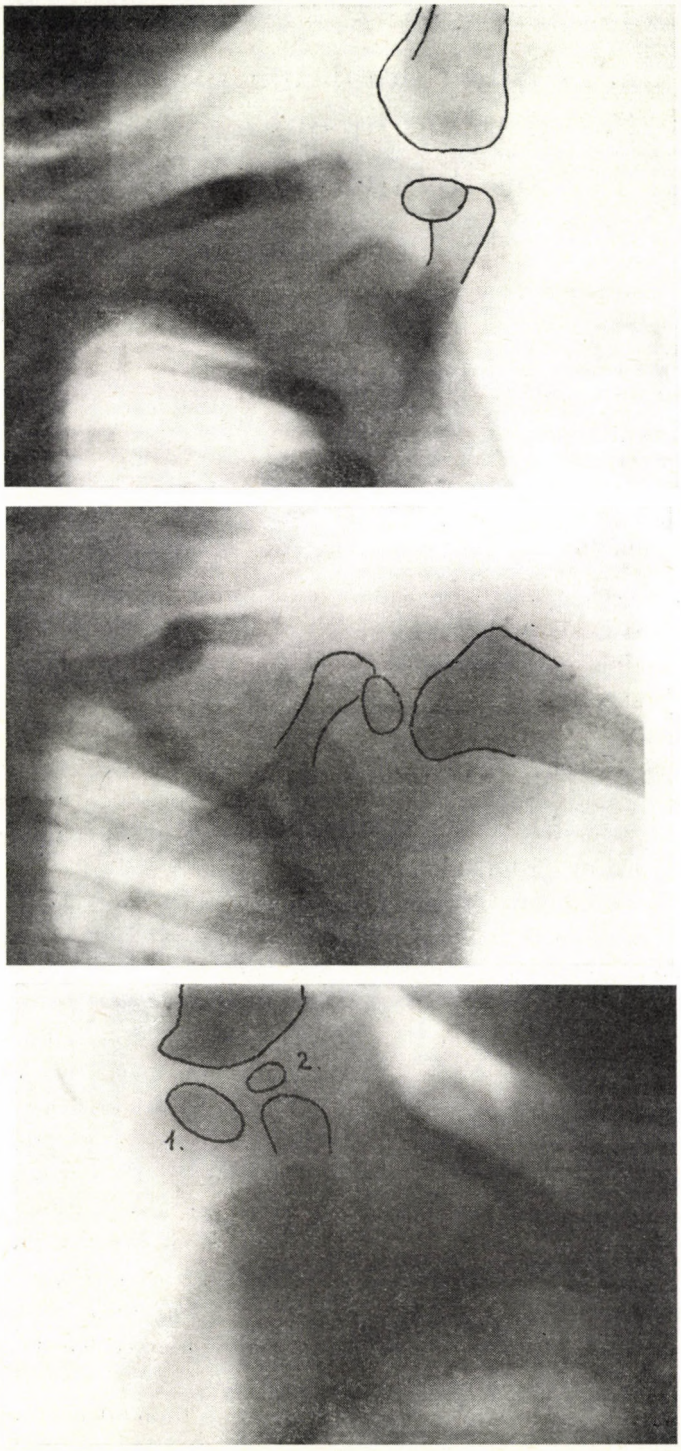

FIG. 1. A — p chest roentgenogram of a 7 months *(a–b)* and a 11 months old *(c)* infant *a* upright, *b* recumbent position. The projections of the medial OC of the same infant are similar. *c* Both the medial (1) and the lateral (2) OC have appeared (upright position).

medial OC is usually present at birth. It is certain to appear during the first three months while the lateral OC becomes visible after the sixth month [1, 5]. Both are easily detected on a–p chest films near the proximal metaphysis of the humerus (Fig. 1).

Materials and Methods

The routine X-ray pictures of the chest have been studied in patients admitted because of some acute disease such as bronchitis, gastroenteritis, hernia, injury, burns, etc. Patients displaying somatic retardation owing to chronic disease, enzymopathy, metabolic disease, etc., were not included. From the age of 1 to 12 months, 100 children were studied for each month of age. Pertinence to an age group was reckoned from the time of birth and that of radiography by adding two weeks to the difference; e.g. infants between two weeks and six weeks were classified into the one month age group.

Measuring technigue. A — p chest roentgenograms at 150 cm focus-film distance were made of infants suspended in upright position. The method can be used in recumbent position too, but the focus-film distance must be longer than 100 cm; in this

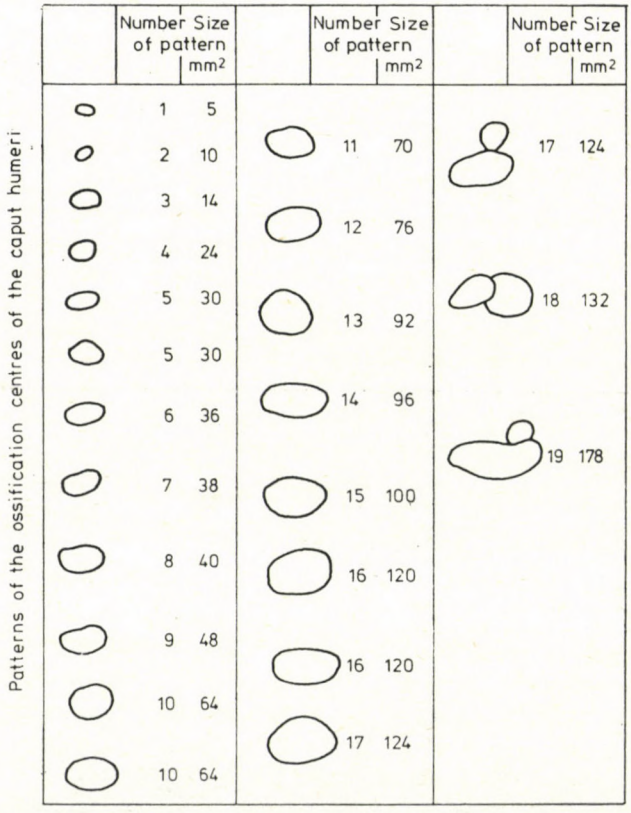

Fig. 2. Pattern set for measurement of the proximal OC of the humerus, and the size of patterns in mm². The set comprises 19 patterns. Nos 5, 10 and 16 are different in shape but identical in size. Size of the irregularly shaped figures is approximate. The size and shape of the centres can be copied on transparent paper or film. Nos 17, 18 and 19 show both the medial and lateral centres

case, projection of the OC is nearly similar (Fig. 1*a–b*).

The roentgenogram is examined on a projector screen and the OC is copied on transparent film. We have done this until we have obtained a pattern for each size, then we prepared sets accordingly and measured the size of each pattern on squared plotting paper (Fig. 2). The pattern proved suitable to measure both the medial and the lateral OC since their shape and development are identical (Fig. 1*c*). In older infants in whom the lateral OC has already appeared, the latter area was added to the medial OC. Thereafter calculations were based on the sum of the area of the two centres. It is not justified to study the two OCs separately, as the head of the humerus ossifies from the two centres. Measurement of OC on both sides gave practically no difference between the two sides in most of the patients. In the case of a minor difference the higher value was used.

Evaluation may be difficult or sometimes impossible when the shadow of the OC projects into the humerus or the scapula, or the X-ray picture is of poor quality. In the latter case a careful study may still allow for differentiation.

Mean and percentile values were calculated.

Results

From 1 month to 12 months the monthly rate of the OC was calculated in both sexes on the basis of the mean values (Table I). The 10th, 25th, 50th, 75th and 90th percentile values were calculated in each age group; they are seen in Fig. 3.

Estimation of bone age on the basis of the pattern set and the percentile table. On the basis of a large number of measurements, the method was found suitable for clinical use. Details of the measurements were as follows:

Measurement of one OC (medial). Using the pattern set, the OC was

Table I

Mean size and monthly growth of ossification centres

Age month	Girls			Boys			Total		
	No. of cases	Mean mm²	Growth mm²	No. of cases	Mean mm²	Growth mm²	No. of cases	Mean mm²	Growth mm²
1	43	6		57	6		100	6.0	
2	44	9	3	56	11	5	100	10.0	4.0
3	49	16	7	51	18	7	100	17.0	7.0
4	45	24	8	55	28	10	100	26.0	9.0
5	51	32	8	49	36	8	100	34.0	8.0
6	44	42	10	56	44	8	100	43.0	9.0
7	43	52	10	57	52	8	100	52.0	9.0
8	47	61	9	53	58	6	100	59.5	7.5
9	39	68	7	61	65	7	100	66.5	7.0
10	51	74	6	49	74	9	100	74.0	7.5
11	49	81	7	51	84	10	10	82.5	8.5
12	37	93	12	63	91	7	100	92.0	9.5

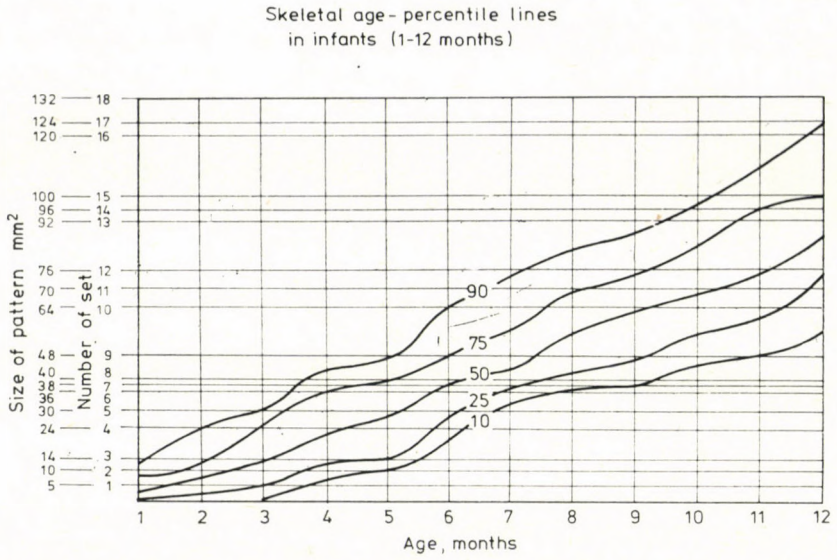

FIG. 3. Percentile graphs of OC development. Abscissa: age in months; ordinate: size of pattern in mm², and number of pattern. For further details, see text

measured and the value looked up on the ordinate of the percentile curve. The intersection of the horizontal line drawn from the ordinate and the vertical line drawn from the age on the abscissa yielded the bone age in percentiles.

Measurement of two OC (medial and lateral). Each of the two OC were measured separately, their area was added and the value determined as mentioned above. Having reached a certain size the two centres ossify together; in such cases the two centres were measured with the last three patterns.

The method was simplified by tabulating the numbers of the patterns corresponding to those sizes of the OC which after minimal correction denote the percentile curve data (Table II).

Bone age is easily determined from Table II in percentiles if one OC is present. If both centres are present the number of the pattern corresponding to the added amount of the two areas is looked up and used for the determination of bone age. The following cases will demonstrate the procedure.

Case 1. For a certain 7 months old infant the number of the pattern was 7. No 7 in Table II corresponds to 25 percentile of actual age, accordingly the baby's bone age is 25 percentile (Fig. 1*a*).

Case 2. If we suppose that the previous infant was 10 months of age, the number of patterns 7 does not figure at 10 months. The nearest number is found at the 10th percentile of 9 months and at 50th percentile at 6 months. Thus, bone age

TABLE II

Estimation of skeletal age on the basis of pattern set in percentiles

Percentiles												
<10				0	1	3	4	5	6	8	8	9
10			0	1	2	4	5	6	7	9	9	10
				2			6	7	8			
25	0	0	1	3	3	5	7	8	9	10	10	11
			2		4	6					11	12
50	1	1	3	4	5	7	8	9	10	11	12	13
				5	6–7	8	9	10	11		13	14
75	2	2	4	6	8	9	10	11	12	12	14	15
		3		7						13		
90	3	4	5	8	9	10	11	12	13	14	15	16
90<		5	6	9	10	11	12	13	14	15	16	17
Age, months	1	2	3	4	5	6	7	8	9	10	11	12

TABLE III

Appearance of the medial ossification centre of the head of the humerus between 1 and 5 months of age

Age, month	Girls			Boys			Total	
	No. of cases	No. of OC	per cent	No. of cases	No. of OC	per cent	No. of cases	No. of OC-per cent
1	43	29	67	57	33	57	100	62
2	44	33	75	56	43	77	100	76
3	49	38	78	51	44	86	100	82
4	45	43	96	55	54	98	100	97
5	51	51	100	49	49	100	100	100

could be 9 months at 10 percentile, or alternatively, 6 months at 50 percentile. These forms allow to establish whether the value is within the variations of a certain age group. Moreover, they show that the value corresponds to the 50th percentile.

Case 3. In this 11 months old infant (Fig. 1*c*) two centres (Nos 10 and 3) were present; the added size of the medial (64 mm^2) and the lateral one (14 mm^2) was 78 mm^2. This is nearest to the pattern No 12 (76 mm^2). According to Table II, the value corresponds to 50th percentile of 11 months.

DISCUSSION

In agreement with data in the literature, the medial OC of the humerus usually appears earlier in girls than

boys during the first month of life [1, 4, 6]. After the second month there is no difference between the sexes (Table III). The monthly growth rate of OC amounts to 7–9.5 mm^2 after the second month (Table I).

As data on the width and height of the OC of the head of the humerus during the first year of life were given only by Schmid [10], we took the same measures; our findings proved to be nearly identical. The monthly size of the OC displayed a considerable scatter. The percentile curves showed, except for the first month, 7–8 size variations in each age group, thus the 10th and 90th percentile curves were rather far from each other. The 50th percentile curve lies slightly below the curve for the mean value in each group. The above mentioned size differences might have been due partly to the fact that the patients studied were not healthy, and partly indicate a wide variability of the size of the OC [4].

Considerable acceleration of the growth of the OC was seen in 3 cases. Aortic stenosis had been diagnosed in 2 of these patients and haemodynamic changes may have been responsible for the increased calcification. In the third patient the clinical symptoms suggested Marshall syndrome [9]. These cases have not been omitted from statistical analysis.

Osseous age determined by the OC of the hands and humerus was compared in some cases (Table IV). Apparently, the method described in the present paper seemed to offer more reliable results than the OC of the hands, especially when the carpal bones appear in an irregular fashion (Case 2) (Table IV, Fig. 4).

The method has the following advantages:

1. The size of the OC can be deter-

TABLE IV

Application of the method

No.	Age months	Sex	Clinical diagnosis	No. of pattern	Skeletal age	
					Humerus month percentile	OC of hand
1	3	m	Adrenogenital	1	3/25	no
	6		syndrome	6	6/25–50	no
	8			10	10/50–75	ab 4 months
2	11	f	Hypothyroidism	9	11/10*	? (Oc of radius)
					8/50**	
3	12	m	VSD	5	7/10*	ab
					5/50**	4–8 months
4	12	m	MPS	5	7/10*	ab
					5/50**	4–8 months

* nearest percentile value,
** 50th percentile value

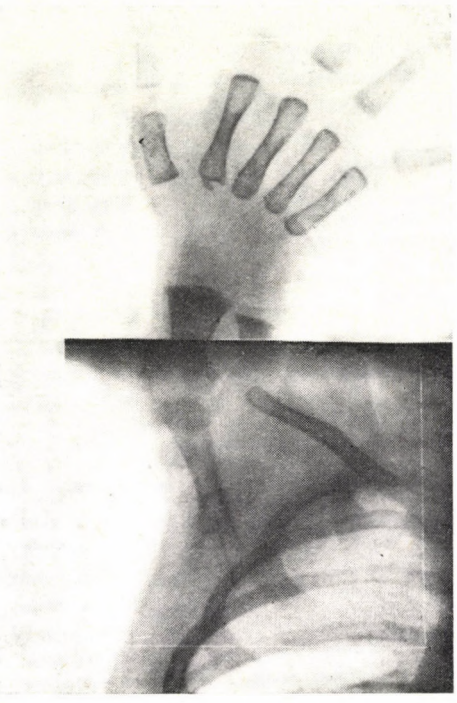

FIG. 4. A — p roentgenogram of the chest and of the hand of an 11 months old hypothyroid infant. For further details, see text

mined from the routine a—p chest roentgenogram. This is still taken of practically every patient admitted to hospital. Additional X-rays are not needed for the determination of skeletal age.

2. The method requires no technical staff in contrast to hand roentgenograms.

3. Bone age can be determined independently from the examiner's impression.

4. The value given in percentiles may complete the similarly expressed values of length, weight, etc.

The method is based on the observation of a single OC although some examiners prefer to determine more centres; in this case, additional X-rays can always be done although in our experience they add little to the information yielded by the head of the humerus. Its late appearance means the only drawback we know in this case some other method should be applied.

ACKNOWLEDGEMENT

I am greatly indebted to Prof. Ch. M. Gefferth for valuable advices.

REFERENCES

1. Caffey J: Paediatric X-ray Diagnosis. Vol 2, Lloyd-Luke, London 1973
2. Elgenmark O: Normal development of the ossification centres during infancy

and childhood. Clinical roentgenologic and statistical study. Acta Paediatr Scand 33 Suppl 1, 1946
3. Erasmie U, Ringeritz H: A method for assessment of skeletal maturity in children below one year of age. Pediatr Radiol 9:225, 1980
4. Gefferth K: Critical evaluation of a method of skeletal age estimation. Magy Radiol 22:300, 1970
5. Groskopff K, Tischendorf R: Das normale menschliche Skelett in Röntgenskizzen. G Thieme, Leipzig 1962
6. Lassrich M, Prévot R, Schäfer, KH: Pädiatrischer Röntgenatlas. G Thieme, Stuttgart 1955
7. Kiss F, Szentágothai J: Atlas of Human Anatomy. 17th ed, Pergamon Press, Oxford 1976
8. Marique P: Aspect radiographique anormale de la tête humérale. Arch Franco-belges Chir 31:236, 1928
9. Marshall R: Syndrome of accelerated maturation and relative failure to thrive: a newly recognized growth disorder. J Pediatr 78:95, 1971
10. Schmid F: Pädiatrische Radiologie. Vol 2, Springer Verlag, Berlin–Heidelberg–New York 1973
11. Senecal M, Grosse A, Vincent J, Simon J, Lefrèche N: Maturation osseuse du foetus et du nouveau-né. Arch Fr Pediatr 34:424, 1977

Received 23 November 1982

B Lombay MD
Szentpéteri k. 72
3501 Miskolc, Hungary