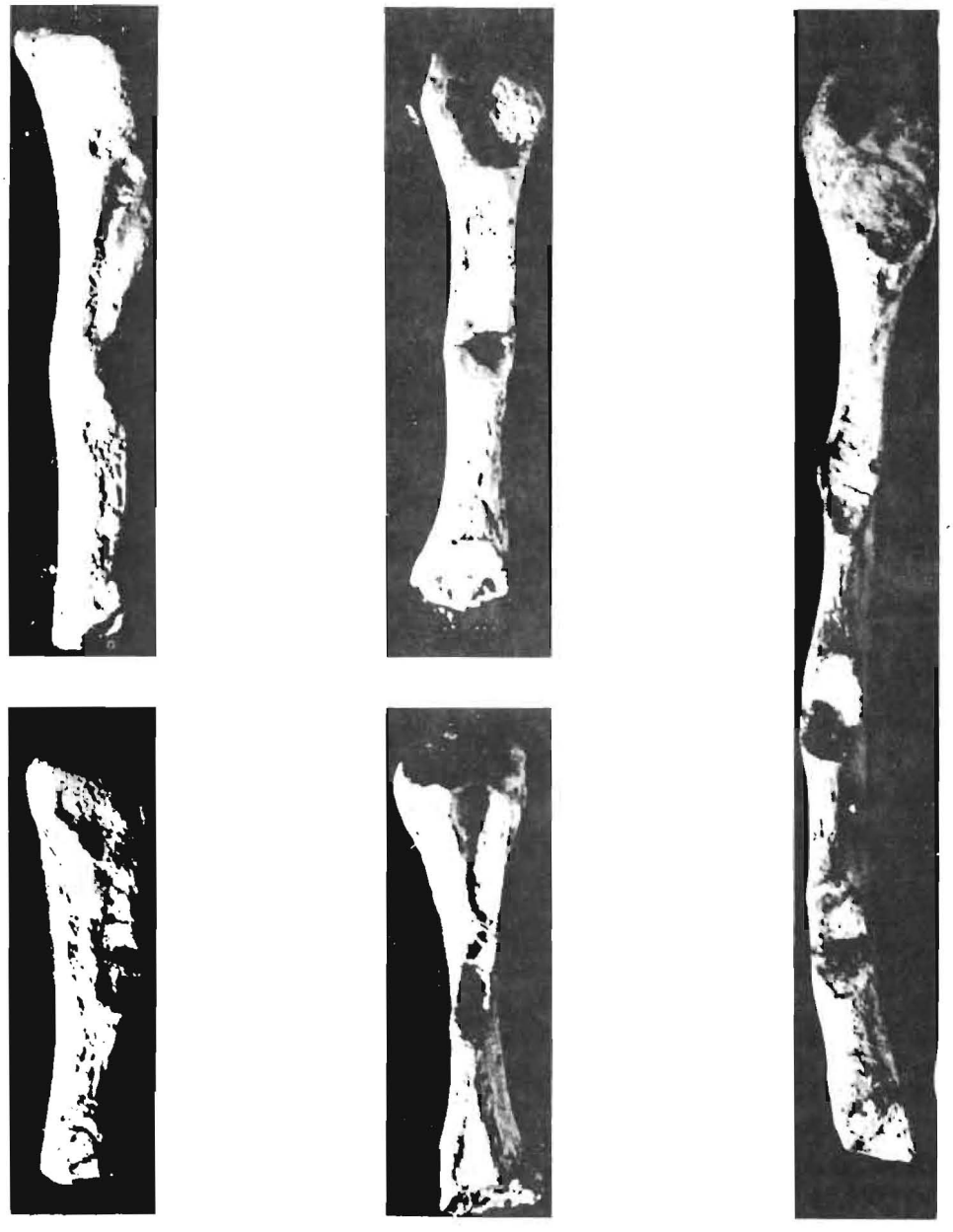

Fig. 70 Casts of the left side of 4 manubria and one manubrium fused with the corpus. The 4 separate manubria are extra long and have costal I notches resembling in texture the clavicular notches. Note the absence of joint thickening in the case where the manubrium is fused with the corpus. (Upper left: No. 22, 21 years; upper middle: No. 428, 33 years; right: No. 176, 25 years; lower left: No. 172, 20 years; lower middle: No. 332, 31 years.)

TABLE 45

DISTRIBUTION OF USABLE AND UNUSABLE COSTAL I NOTCHES BY AGE

Age	No. of Cases	Manubrium Missing	Notch Damaged	Notch Anomalous One Side	Notch Anomalous Both Sides	Usable Spec. No.	Usable Spec. %
17-18	55	10	18	4	1	26	47.3
19	53	9	14	1	2	28	52.8
20	45	4	12	3	4	25	55.5
21	39	3	9	3	3	24	61.5
22	25	6	2	-	-	17	68.0
23	27	3	7	2	2	15	55.6
24-25	28	1	2	3	7	18	64.3
26-27	25	-	2	7	1	22	88.0
28-30	29	1	2	3	1	25	86.2
31-40	43	-	-	4	4	39	90.7
41-50	6	1	-	-	1	4	60.7
Totals	375	38(10.1%)	68(18.1%)	30(8.0%)	26(6.9%)	243	64.8

specimens from analysis. In addition, the manubrium was not recovered in some cases. It is important to note, therefore, that after approximately 4 years of burial in Korea, and in spite of careful disinterment, the costal I notch is fully utilizable for age identification in only about half the cases around 17-19 years of age, and in about two-thirds of the cases between 20-25 years of age. Given different burial conditions the state of preservation might, of course, be worse or it might be much better.

As in the case of the clavicular notch, the original observations on costal I notch were judged to have been influenced by knowledge of other maturational features. Since, however, a cast had been made of one side of the manubrium in each case, new observations were made on the casts without reference to the findings on the rest of the skeleton. The following statements are based mainly on these new observation.

An essential part of the maturation and resultant differentiation of the clavicular and costal I notches is the obliteration of the anterior, or ventral, interarticular groove (Stewart, 1954, p. 525). It is clear in a number of cases that the medial portion of this groove is filled in by an extension of the epiphysis for the clavicular notch (Fig. 71). How otherwise the groove is filled in is rarely clear, but certainly most cases reach maturity without a trace of the groove. Yet in a small percentage of cases the anterior superior border of the costal I notch may appear to be defective well after the first half of the third decade. Such defects in older

age groups probably do not represent a persistence of the interarticular groove, but rather an irregularity of ossification. Often the border between the two notches is the site of one or more separate ossific elements which may or may not unite with the manubrium. Union seems to be indicated when the border between the two notches is unusually prominent; nonunion is indicated when the usual sharp border is replaced by one or more facets (Fig. 72). Thus, although it seems likely that the last traces of the interarticular groove disappear by 22-23 years, it becomes necessary to base this judgment on the appearance of the costal I notch as a whole.

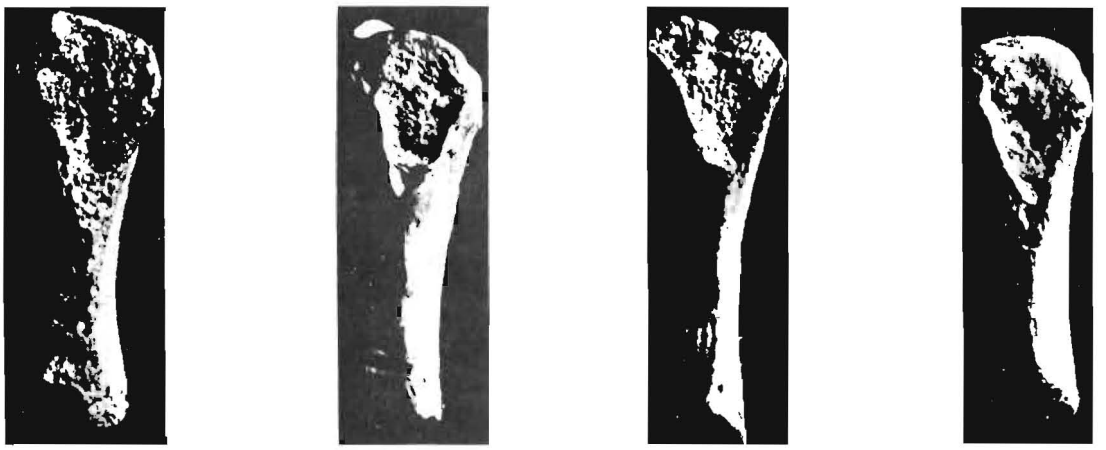

Fig. 71 Casts of left side of 4 manubria showing successive stages of the filling in of the interarticular groove, seen here at the upper left margin of the costal I notch (Left to right: No. 74, 21 years; No. 234, 24 years; No. 187, 26 years; and No. 78, 28 years).

While the interarticular groove is disappearing, the concavity of the costal I notch is also undergoing changes. Here the matte-like, billowed surface so typical of the immature joint tends to become smoother and yet more porous. Stewart (1954, p. 524) noted the presence at this stage of plaques of bone and judged them to be epiphyses. In the present series only the best-preserved specimens--that is, the ones listed in the last column of Table 45--could be expected to show this feature. Examination of the casts of these specimens revealed 39 with plaques between the ages of 18 and 24. The highest incidence was between 19 and 21 years. In view of the fact that these 39 cases represent only a little over 25% of the specimens examined, it is apparent that this feature by itself is of little utility for age identification.

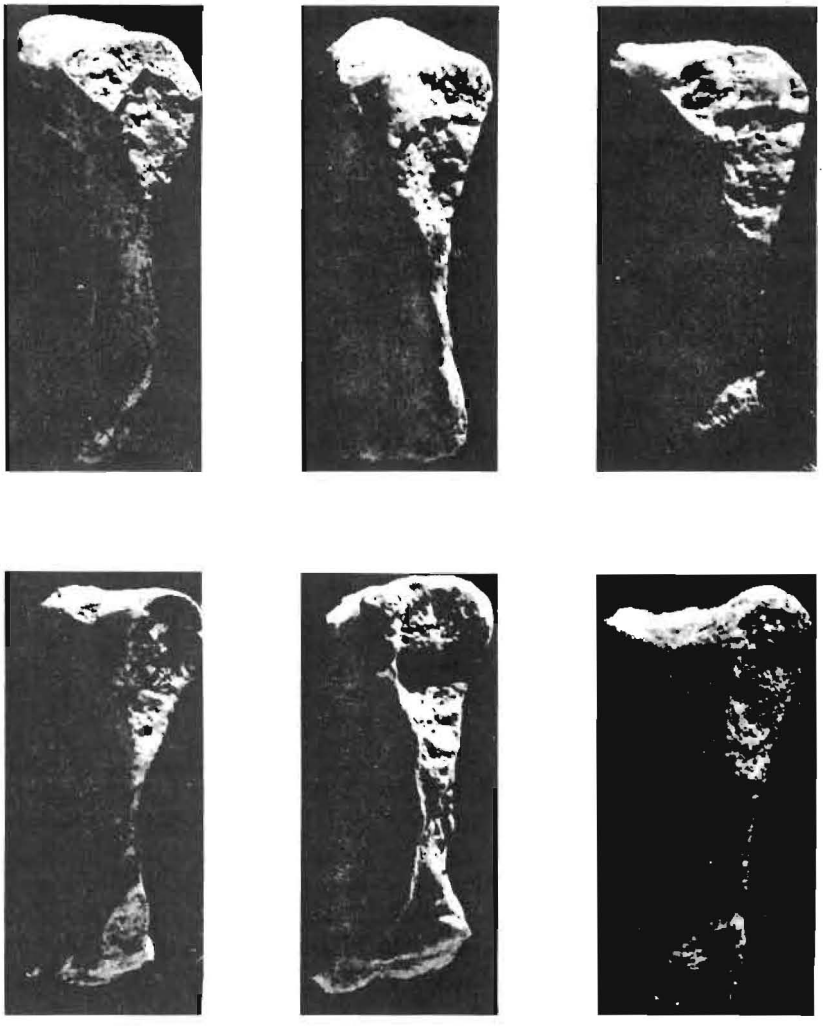

Fig. 72 Top row: Casts of 3 manubria showing costal I notches with a faceted area in the upper portion. (Left: No. 124, 18 years; middle: No. 321, 20 years; right: No. 299, 21 years).

Bottom row: Casts of 3 manubria showing ossific nodules attaching or attached to the facets. The addition of this element increases the prominence of the angle between the clavicular and costal I notches. (Left: No. 106, 22 years; middle: No. 3, 20 years; right: No. 90, 22 years).

Note the middle cast in each row is of the right side; all others are of the left side.

Returning now to the costal I notch as a whole, the signs of immaturity include remnants of the interarticular groove, a billowed and matte-like surface, the presence of plaques resembling epiphyses, and the absence of sharp margins and prominent angles. Ideally, one would like to analyze these features in somewhat the same way as we have done for the face of the pubic symphysis. However, in view of the difficulties already stated, and the fact that all of the features occupy a relatively small area, such an analysis has not seemed feasible. Instead, after arranging the casts of the manubria by age from 17 to 26 years and studying the costal I notch of each carefully, one of us (T.D.S.) undertook to separate them into three groups: 1) those obviously immature (Fig. 73, top row); 2) those with traces of immaturity (Fig. 73, middle row); and 3) those with no easily recognizable signs of immaturity (Fig. 73, bottom row). Table 46 shows the results of this sorting. Here it will be seen that obviously immature costal I notches steadily decrease from about 85% at the beginning of our series (17-18 years) and disappear after age 23, becoming scarce indeed after 21; that less obviously immature notches are already present at 17-18 (15.4%) and increase to age 20, then decrease through the next 5 years, disappearing thereafter; and also that seemingly mature notches begin to appear about age 21 and reach 100% at 26.

TABLE 46
PROGRESS IN MATURATION OF THE COSTAL I NOTCH
(BASED ON CASTS OF ONE SIDE OF THE MANUBRIUM)
(in %)

Age	Usable Cases (No.)	Obviously Immature	Suggestive of Immaturity	Not Evidently Immature
17	5	100.0	-	-
18	21	81.0	19.0	-
19	28	57.1	42.8	-
20	25	44.0	56.0	-
21	24	33.3	37.5	29.2
22	17	17.6	47.0	35.3
23	15	13.3	33.3	53.3
24	9	-	55.6	44.4
25	9	-	11.1	88.9
26	13	-	-	100.0

Since the costal I notches shown in Figure 73 were selected to demonstrate the range of variation at each age, and since the signs of immaturity in this joint surface disappear with age, the result is essentially a maturational progression from one row to the next; in other words, the last specimen in the first row is at about the same stage of maturation as

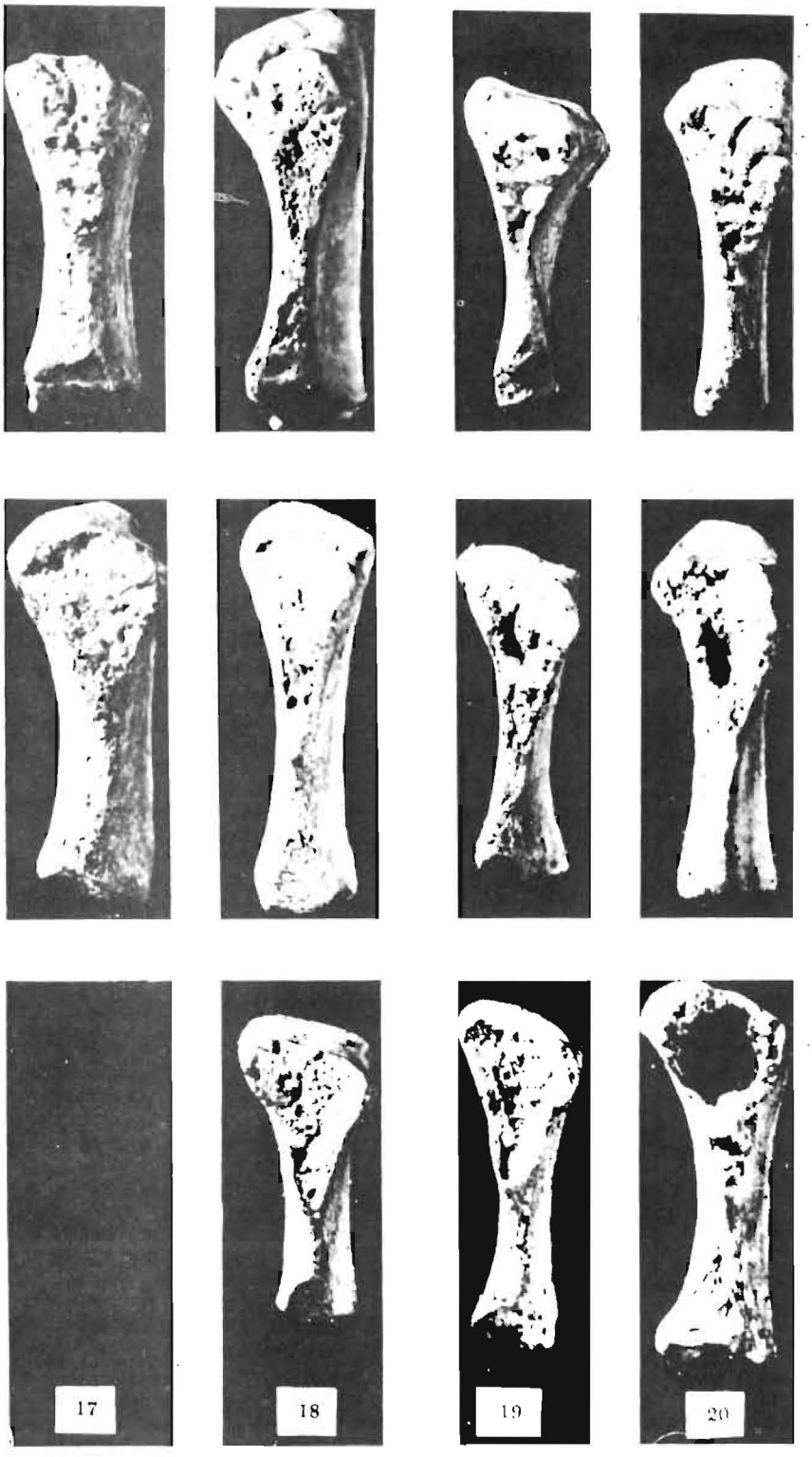

Fig. 73 Selection of manubria from ages 17 to 25 showing: (top row) obvious immaturity, (middle row) less obvious immaturity, and (bottom row) essentially complete maturity. The top and bottom rows (and the middle row in three instances) represent extremes for the ages shown. (Top row: Nos. 96, 317, 320, and 311; middle row: Nos. 11, 10, 178, and 321; bottom row: Nos. 212, 220 and 41).

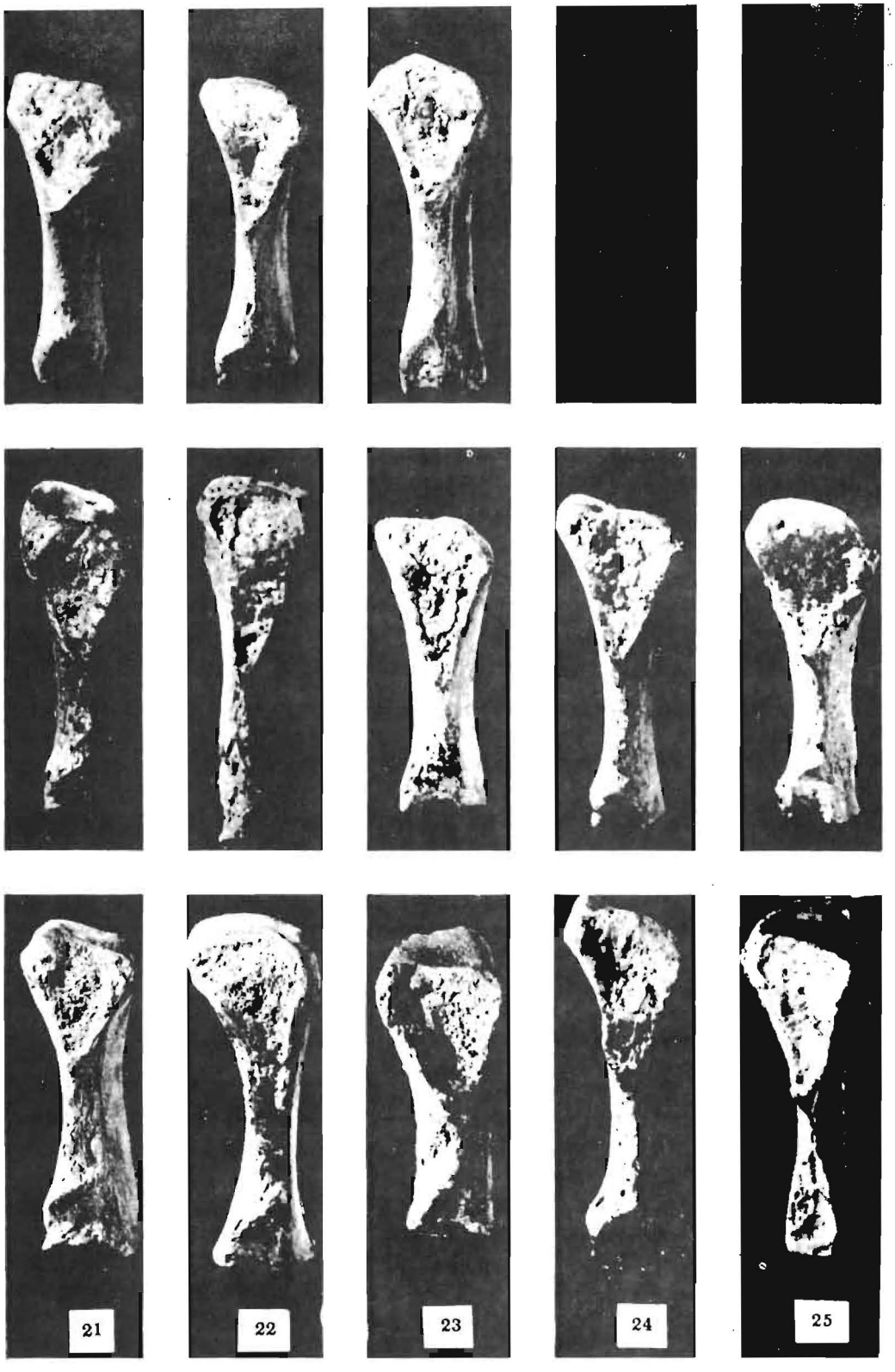

Fig. 73 continued. (Top row: Nos. 203, 229, and 26; middle row: Nos. 7, 118, 85, 231 and 340; bottom row: Nos. 190, 330, 13, 37 and 111).

the first specimen in the second row, and likewise the last specimen in the second row resembles the first specimen in the third row. Besides showing the great amount of variation in the costal I notch, Figure 73 makes it clear that experience is required to interpret the signs of immaturity here.

After 25 years, when all signs of billowing are gone from the surface of the costal I notch, the main noteworthy change is the development of exotoses along the margins.* These exotoses are in addition to the attachment of ossicles at the upper extremity as already described, and as illustrated in Figure 72. Although the upper extremity of the notch is mainly involved in both processes, quite commonly a characteristic small spur develops at the inferior extremity (Fig. 74). Although these marginal exotoses are not altogether limited to the ages beyond 25, they probably represent ossification of the costal cartilage. Two extreme cases of such ossification, in which the whole external surface of the cartilage has turned to bone, are shown in Figure 75. Even in these extreme cases a joint was maintained between the first rib and the manubrium, but the position of the joint differed, being at the costal end of the cartilage in one case and at the sternal end in the other. Obviously, as the margins of the costal I notch become prominent the enclosed surface assumes a more concave appearance.

At the time the original observations were made, Dr. Stewart thought that in general the feature described in the preceding paragraph would show steady progression with age and thus might prove useful for ageing purposes. Therefore he graded subjectively all cases on the usual scale of 0-4, differentiating as far as possible the exotoses and the fused ossicles at the superior extremity. On reviewing the results, only case 216, shown at the left side of Figure 75, qualifies for grade 4 (case 360, shown in the middle of Figure 75, is not nearly as impressive without the ribs). A true grade 3 also appears to be rare (case 239, shown at the right side of Figure 75 is nearest; case 9, shown in Figure 74 also was given this rating).

Table 47 shows that the expected general trend is present, but that the progression with age is not sufficiently uniform to be of real use for ageing purposes. From the practical standpoint it appears that slight exostoses (grade 1) occur on the margins of the notch at all ages between 21 and 50, but that larger exostoses (grades 2-4) are unusual before the age of 30.

*On the record card this observation was included in the category "arthritis." This categorization was more a matter of convenience than an indication of assigned significance.

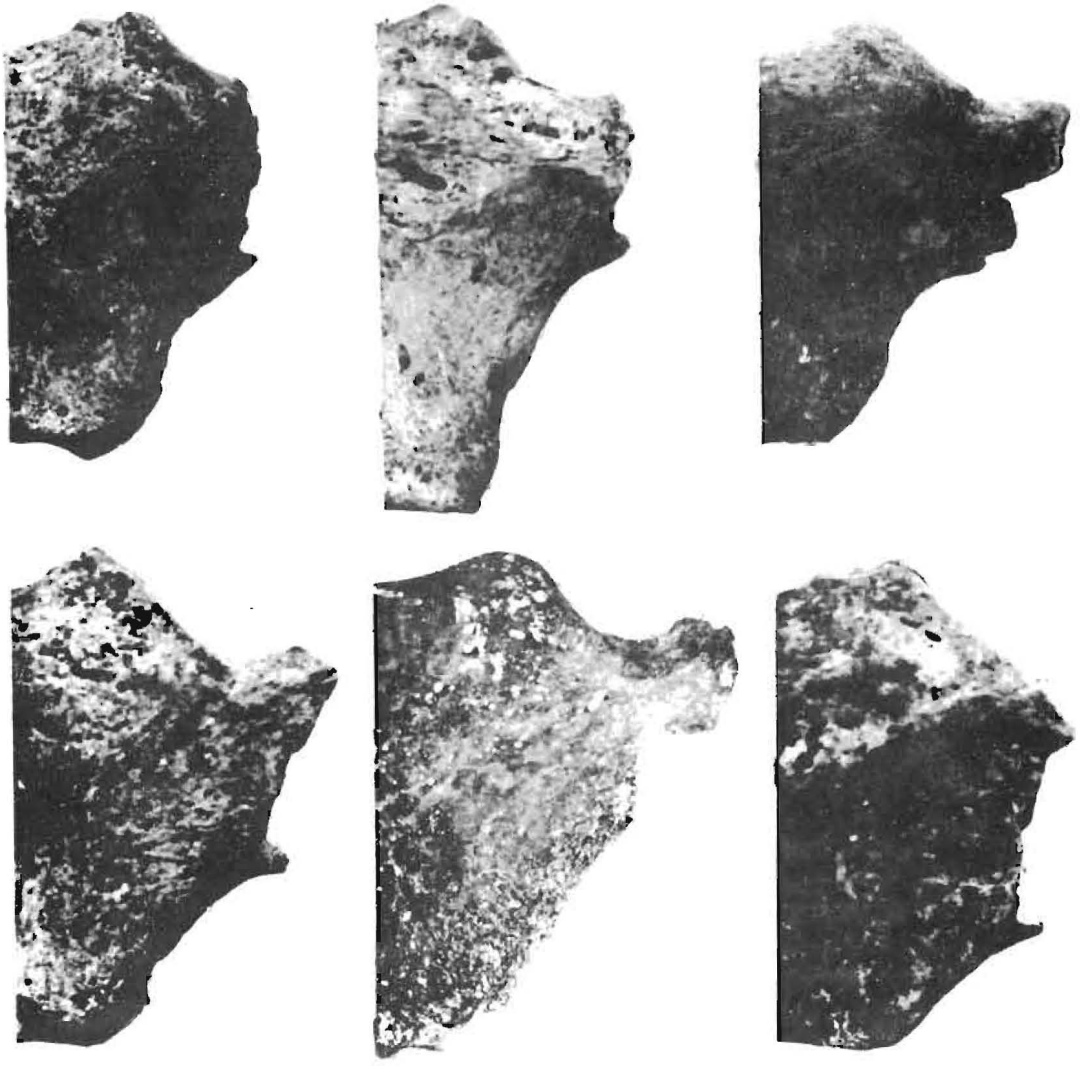

Fig. 74 Front view of the left side of a selected group of manubria between the ages of 25 and 36. Note that the outline of the costal I notch becomes distorted by extensions from the margins, particularly at the superior extremity, but also to a lesser extent at the interior extremity. These extensions are ossifications of the exterior of the costal cartilage and result in the surface of the notch becoming more and more concave. (Right to left, upper row: No. 426, 25 years; No. 450, 30 years; No. 336, 30 years. Lower row: No. 442, 31 years; No. 9, 32 years; No. 354, 36 years.)

Fig. 75 The most extreme cases observed of ossification of the first costal cartilages. Note that in the middle specimen (age 32) the ribs have captured the ossified cartilages, whereas in the specimen on the left (age 38) the manubrium has captured the cartilages. The specimen at the right (age 29) shows less ossification of the cartilage (stage 3 vs. stage 4). Synostosis between the corpus and the xiphoid is also present in the two specimens on the left. (Left to right, Nos.: 216, 360, 239).

TABLE 47

EXOTOSES ALONG THE MARGINS OF THE COSTAL I NOTCH, BY SIZE AND ACCORDING TO AGE
(in %)

Age	No. of cases Observed 1/	No Exotoses	Exostoses Present Slight(1)	Medium(2)	Moderate(3)	Large(4)
21-23	73	94.5	5.5	-	-	-
24-25	25	80.0	20.0	-	-	-
26-27	25	68.0	28.0	4.0	-	-
28-30	26	38.5	42.3	15.4	3.8	-
31-35	28	25.0	53.6	14.3	7.1	-
36-40	15	13.3	40.0	26.7	13.3	6.7
41-50	5	-	40.0	20.0	40.0	-

1/ Cases not recorded: 18 in 21-23 age group, 3 in 24-25 age group, 3 in 28-30 age group, 1 in 41-50 age group.

6. Summary

A comparison is now in order between the present findings and the tentative findings of Stewart (1954), quoted at the beginning of this chapter, which are based on materials from archeological sources in North America.

1. Fusion of the component elements of the corpus sterni was observed to be essentially complete in most cases by 22-23 years, although rarely the uppermost segment was found still separate as late as 27 years. Signs of recent union not infrequently were observed to persist in the depths of the costal III and IV notches throughout the third decade. Stewart suggested that signs of recent union could persist to 30 years, but he was inclined to give a slightly earlier age for the main stage of segmental fusion.

2. In a considerable number of sterna the manubrium appeared to have captured the uppermost segment of the corpus. In some of these cases the related costal notches also had an anomalous character. This is a factor complicating the statistics on segmental fusion which Stewart did not take into account.

3. The epiphyseal plate for the surface of the clavicular notch, although seldom observable, was recorded as uniting between 18 and 22 years, with greatest activity at 19 years. Stewart suggested that this event occurred at 19-20 years.

4. No clear end point was discovered for the obliteration of the ventral interarticular groove, on account of the variable presence of ossicles (or facets thereof) at the superior extremity of the costal I notch. Judging from the maturation of this notch as a whole, a true groove does not persist beyond 23 years (Stewart estimated between 20 and 23 years).

5. The costal I notch was found to be damaged or anomalous, and hence not usable for analysis, in a high percentage of cases (half of the cases around 17-19 years, and two-thirds of the cases between 20 and 25 years). These figures, and especially the part due to anomalies, probably could not have been anticipated.

6. Plaques (epiphyses ?) were seen in the concavity of the costal I notch in 39 cases between the ages of 18 and 24. The highest incidence was between 19 and 21 years. Stewart placed this event at 19-20 years.

7. Obviously immature costal I notches were not found after 23 years. All signs of immaturity were judged to have disappeared from this notch by 26 years. Stewart did not use this method of analysis.

8. Cases in which the costal I notch exhibited a slightly raised rim were found at all ages between 21 and 50 years (Stewart suggested 20-30 years), but cases with sizable spurs or exostoses were rarely seen before 30 (Stewart suggested about 35 years).

This comparison shows that Stewart came fairly close in his estimates of age for maturational events in the sternum, but that he failed to detect the extent of the variability in this bone among different racial groups.* So much variability in Whites is disappointing from the standpoint of age identification and somewhat surprising. Thus the question arises whether the sternum in modern Whites is more variable than in American Indians and Eskimos.

*Stewart used skeletal material from both American Indians and Eskimo collections for his 1954 study.

CHAPTER IX

SACRUM

1. Introduction

The sacrum is that section of the vertebral column which normally fuses into a single bone and forms part of the pelvis. Usually the sacrum consists of 5 segments, but it may have as few as 4 or as many as 6. At the age of 17 the segments are still incompletely united and the epiphyses for the top surface of S1, the lateral articular area and the lateral edge, caudad of the articular area, have just begun to unite.

The only direct observations recorded for the sacrum were the states of fusion of the joints between the centra of S1-2 and S2-3. These observations were supplemented by two photographs (the anterior surface, and lateral articular area) which were used to confirm the observations and to analyze the state of union of the marginal epiphyses.

2. Historical Remarks

The sacrum is another area of the skeleton where few studies exist that are specifically related to patterns of ossification. Stevenson (1924) does not include the sacrum in his study of epiphyseal maturation and Flecker (1942) limits his observations to the appearance of ossification centers. However, he refers to a study by Cleaves (1937) who analyzed the auricular (articular) epiphyses in repeated stereoscopic roentgenograms of 16 American boys ranging in age from 12 to 19 years. Though his sample at ages 18 and 19 consisted of only 4 and 2 cases respectively, he concluded that fusion of the auricular epiphysis takes place in the majority of boys at the age of 18.

The most generally used information on the development of the sacrum comes from those sections on ossification in anatomy textbooks. The lack of supporting research is reflected in the general disagreement among the textbook writers on the age at which the elements of the sacrum are united. For example, Cunningham's section on the ossification of the sacrum states (p. 120) that "...the epiphyses fuse with the bodies and the bodies fuse together from below upwards between 18 and 25", whereas Grey's Anatomy claims (p. 109) that "...about the eighteenth year the lowest segments became united by bone, with the result that between the twenty-fifth and

thirtieth years of life all the segments are united." On the basis of these representative statements, it would seem that the state of our knowledge concerning sacral maturation leaves much to be desired, especially as it is applied to problems of age identification.

3. Epiphyseal Union

Fig. 76 shows the earliest maturative stages of the sacrum encountered in our series. It is evident here that at this age (17 years) the segments are incompletely fused and the marginal epiphyses ununited or just beginning to unite. This being the case, it is desirable to know the date of disappearance of all such signs of immaturity. To this end we have not only analyzed the direct observations on the union of S1-2 and S2-3 but have examined all photographs. Since we had anterior and lateral views to compare, there is seldom any doubt about the status of union of any particular epiphysis. The results are summarized in Tables 48 and 49.

TABLE 48

AGE DISTRIBUTION FOR STAGES OF UNION BETWEEN THE SEGMENTS OF THE SACRUM (in %)

		S4-5					S3-4					S2-3					S1-2				
		Stages					Stages					Stages					Stages				
Age	No.	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4
17-18	55	7	5	7	22	47	8	6	14	48	24			25	45	30	1	3	23	70	3
19	52		2	4	29	65		2	7	40	51			11	28	61		4	9	81	6
20	45				26	74				21	79			9	27	64		2	9	67	22
21	39				14	86			2	18	80			5	27	68		2	8	66	24
22	24				8	92				12	88				20	80			4	63	33
23	26					100					100				8	92				63	37
24	14															100				35	65
25	13																			30	70
26-27	25																			55	45
28-29	19																			56	44
30-32	27																			37	63
33+	34																				100
Total	373																				

As illustrated in Figs. 76 and 77 the lowermost sacral bodies unite from below upwards. This order of union is further demonstrated in Table 48. Here, the S4-5 and S3-4 joints show completed union at the age of

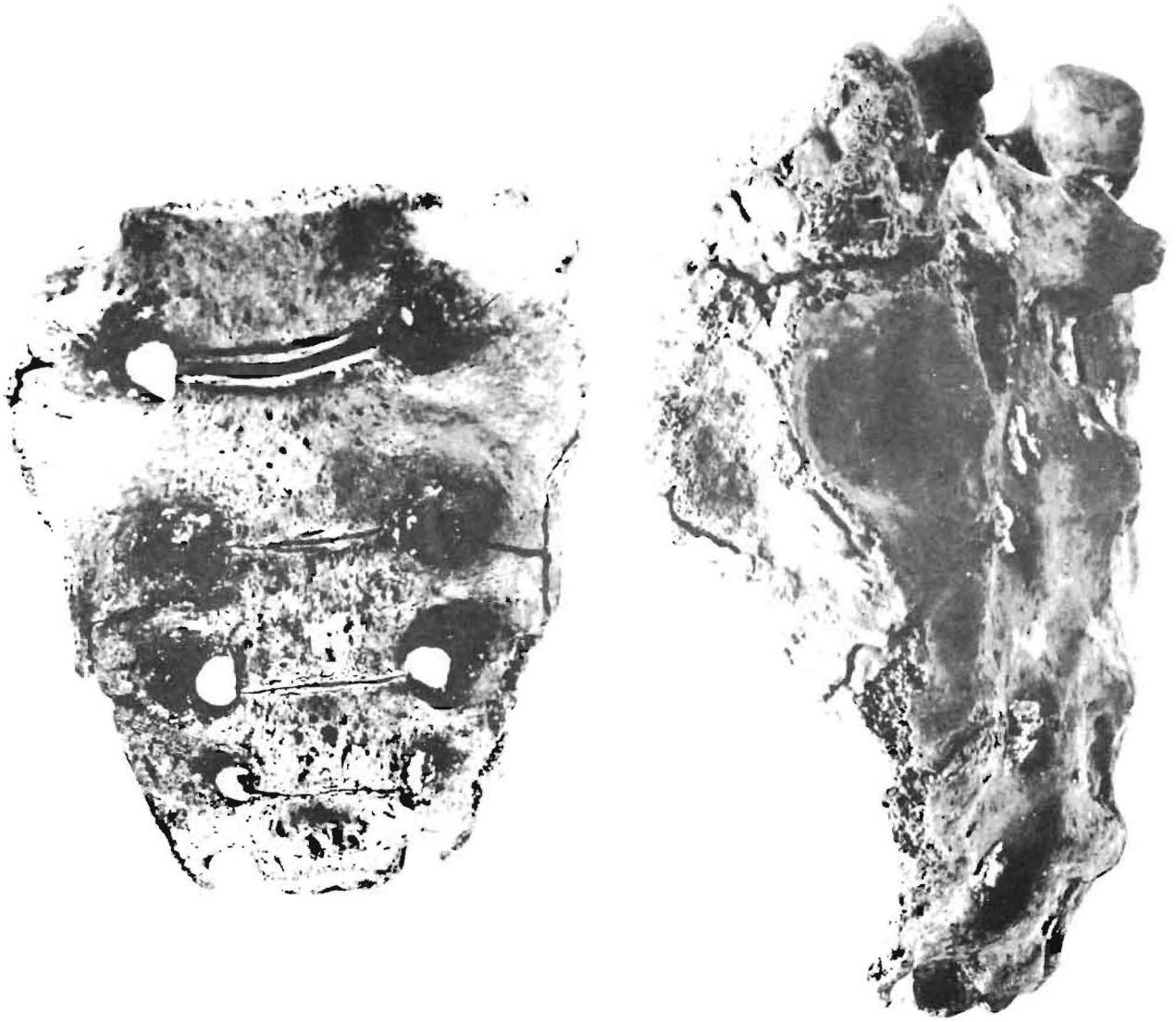

Fig. 76 Anterior and lateral surfaces of the sacrum showing earliest maturative stages encountered in our series. (No. 202, 17 years).

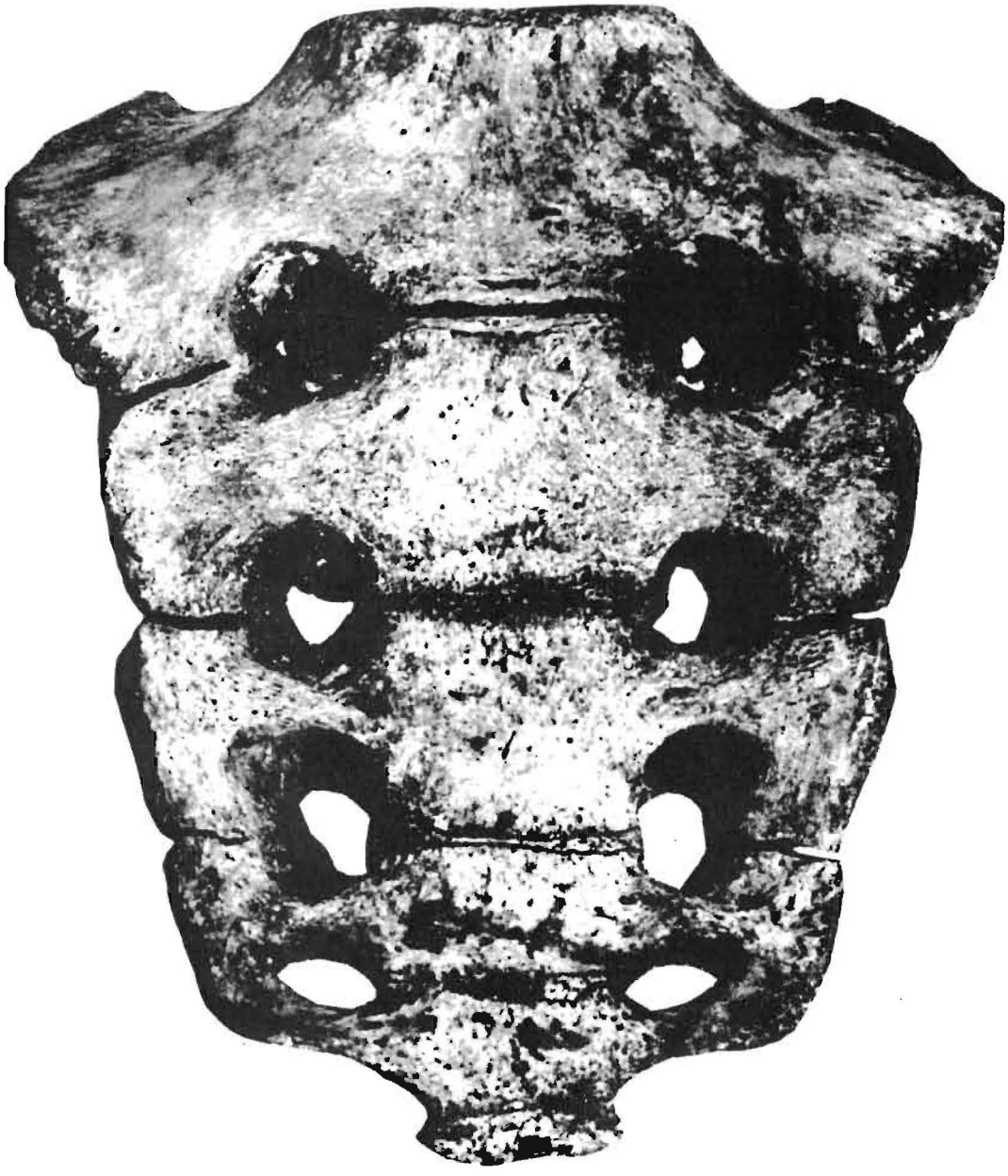

Fig. 77 Anterior surface of sacrum showing incorporation of superior and inferior rings with the intervertebral disks. (No. 30, 18 years).

TABLE 49

AGE DISTRIBUTION OF STAGES OF UNION FOR THE MARGINAL EPIPHYSES OF THE SACRUM. (in %)

		S1: Sup. Epiphyseal Ring					Lateral Joints					Auricular Epiphysis				
		Stages					Stages					Stages				
Age	No.	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4
17	10	30	10	20	30	10	-	20	30	50	-	20	50	20	10	-
18	45	2	6	14	45	33			14	54	32	2	16	42	28	12
19	52	2	2	7	22	67			10	37	53	2	7	10	44	36
20	45				8	92				29	71			2	41	57
21	39				6	92				13	85			2	13	85
22	24					100					100					100
Total	215															

23 years with the former slightly in advance. By contrast, the S2-3 and S1-2 joints at this age are still in active stages of union; they complete their maturation at 24 and 33 years respectively. However, the progress of union for the S1-2 joint exhibits irregularity between the ages of 26 and 30, or just before the joint becomes completely fused. The explanation for this irregularity probably lies in the drawn-out process of terminal ossification and the consequent difficulty in determining when maturation is complete. Sometimes when examining these cases of delayed union it was tempting to regard them as comparable to the so-called "lapsed union" found in sutures (Todd and Lyon, 1924, p. 337). It was also observed that the gaps are probably related to the varying distances that separate the segments. Where the space between the sacral elements is small, ossification is more likely to be complete early (Fig. 78), whereas widely separated segments will often exhibit incomplete ossification in the form of medial gaps (Fig. 79). Thus, a persistent gap at the S1-2 level requires careful evaluation.

As will be recalled, we have followed the progress of union of the superior and inferior rings of the presacral centra. In the sacrum, most of these rings are incorporated with the intervertebral disks in the process of ossification (Fig. 77) and only the one on the superior surface of the first segment fuses in the same manner as its presacral counterparts. Referring to Table 49, the first column shows the maturative progress of

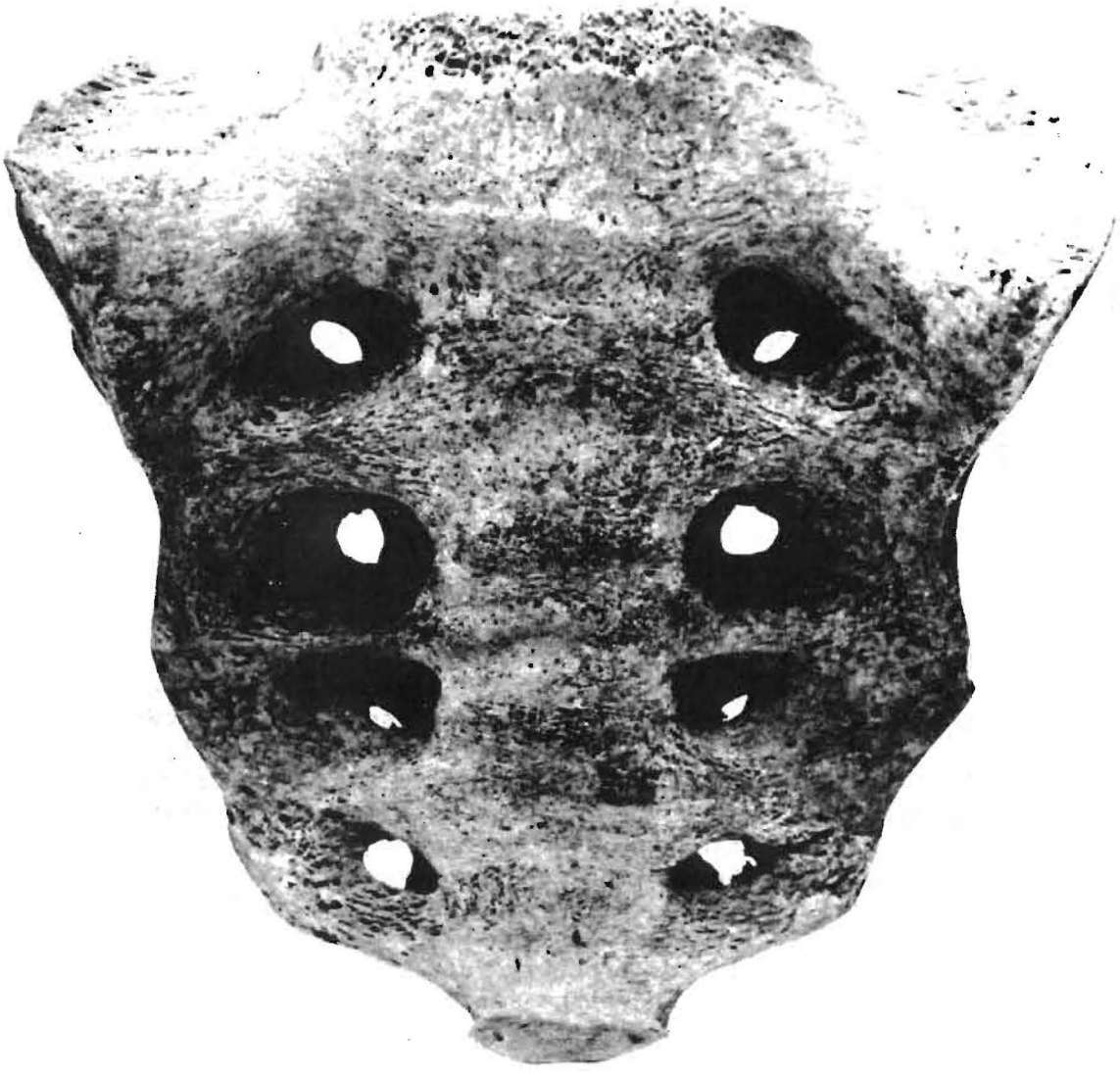

Fig. 78 Anterior surface of sacrum showing completely united segments. (No. 216, 38 years).

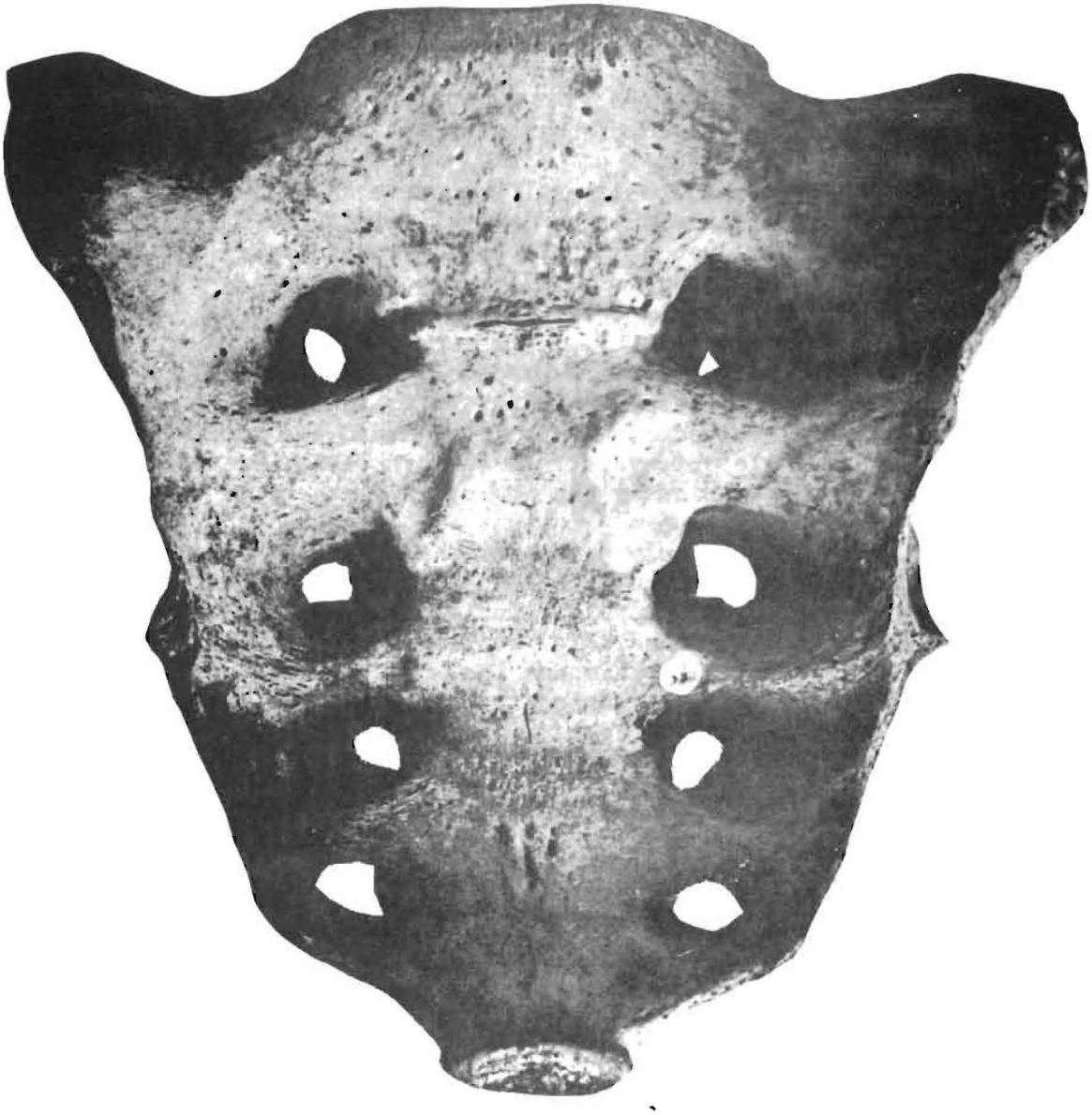

Fig. 79 Anterior surface of united sacrum showing medial gap between segments 1 and 2. (No. 16, 22 years).

this ring and demonstrates its complete fusion by 22 years of age.

The sacrum fuses through the lateral processes as well as through the centra. According to Table 49, the lateral joints are fully united by the 22nd year, that is, just ahead of the lowermost centra. Note too that last remnants of union occur as shallow grooves, usually at the level of the 2nd and 3rd segments (Fig. 80).

The epiphyses for the articular surface of the sacrum and for the lateral edge, caudad to the articular area, vary in length according to the number of segments involved. We have disregarded the subdivisions and considered them as a single epiphysis. As seen in Table 49, the articular epiphysis reaches complete union by the age of 22 years.

Beyond this age, we can only point out the general distinction between the appearance of the articular surfaces in young and old. Fig. 81, left, shows this surface in a 20 year old individual. Note the smooth and rounded relief. On the other hand, Fig. 81, right, shows the same surface in a 33 year old individual. By this age the surface has become rough and eroded with a sharp and irregular anterior margin. These changes are not orderly enough to be useful in ageing.

4. Summary

The several elements comprising the sacrum begin to fuse from below upwards and along the sides. By 23 years ossification is complete except often between the S1-2 centra, where a gap may persist until the 32nd year. This gap seems to represent a sort of "lapsed union" which may be related to an extra wide intersegmental space.

The lateral joint surfaces of the sacrum also undergo gradual changes but these are not very useful for ageing purposes.

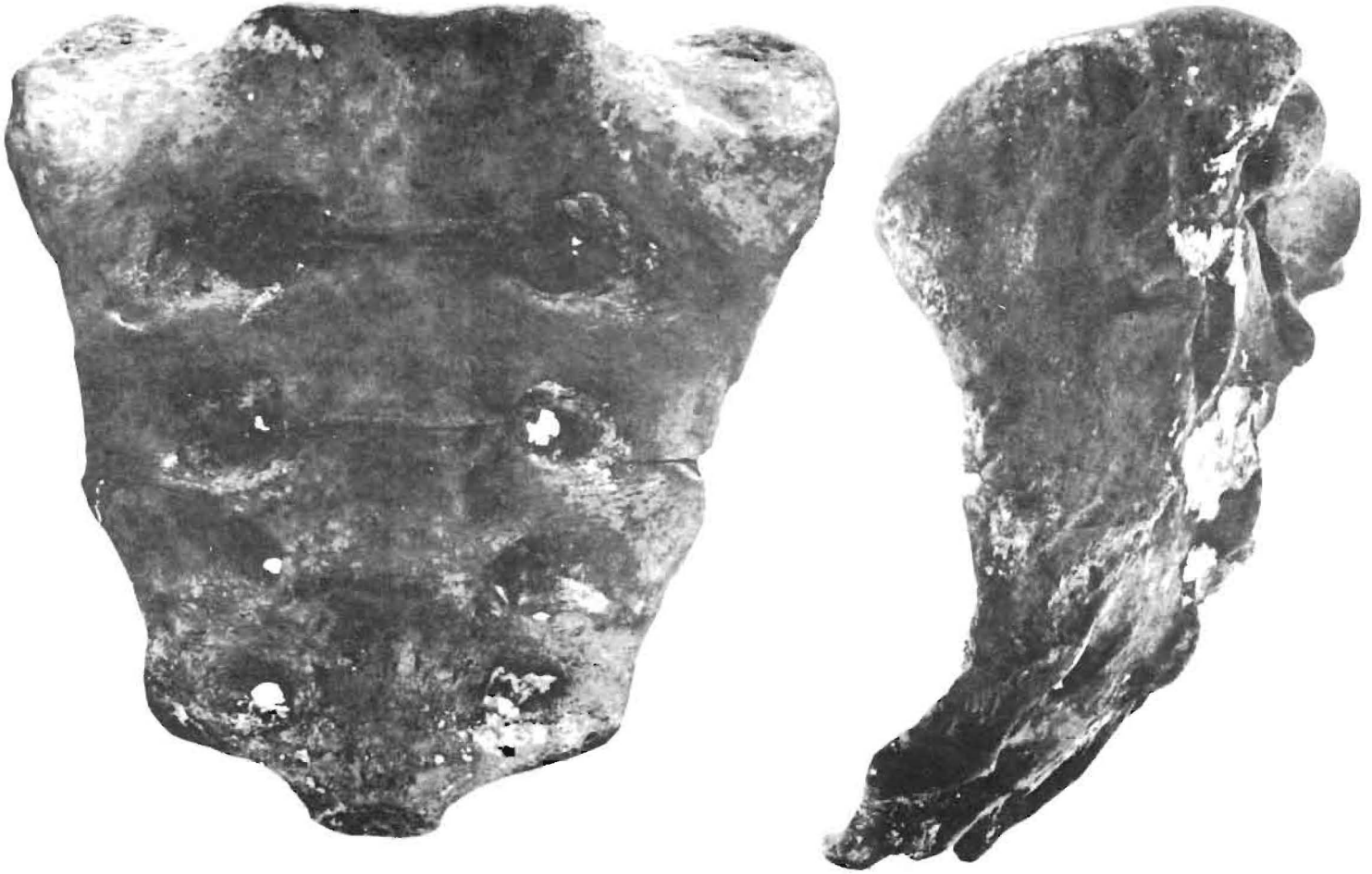

Fig. 80 Anterior and lateral surfaces of the sacrum showing late stages of union for the lateral joints. (No. 174, 20 years.) Note shallow fissures at level of 2nd and 3rd segments.

Fig. 81 Left lateral views of sacra showing auricular surface of young (left, No. 153, 20 years) and older (right, No. 418, 33 years) individuals.

CHAPTER X

RIBS

1. Introduction

Usually there are 12 pair of ribs which articulate posteriorly with the thoracic vertebrae. Epiphyses are located at the points of articulation: namely, 1) on the head (single), and 2) on the tubercle (often double) (Fig. 82).

No provision was made on the data sheet for recording stages of epiphyseal union for the ribs but it was decided to make notes on the epiphyses of the heads. The epiphyses for the tubercles were not recorded because of the difficulty of interpreting their status of union; they are among the smallest in the skeleton and their appearance is much the same before and after union.

Fig. 82 The 6th (left) and 11th (right) right ribs showing location of the epiphyses (head and tubercle). Note that the head epiphysis of the 11th rib is in stage 1 of union as is the epiphysis of the tubercle for the 6th rib. (No. 2, 19 years).

In each case the ribs were arranged in anatomical order so that the serial number of each could be easily identified (Fig. 83). Also, each head epiphysis, on both right and left sides, was recorded simply as united or ununited.

2. Historical Remarks.

Most anatomy textbooks state simply that the epiphyses for the ribs unite around 23 years of age. Stevenson (1924) records, in general and not individually, observations on the union of the rib epiphyses. He concludes (p. 73) that, "they are found to be united in all cases after the twenty-second year." X-ray studies have contributed little if anything to this subject. For example, Flecker (1942) limits his discussion of the ribs to two short paragraphs on the number of ribs present in fetuses. No mention of the ribs is found in his final chronological summary.

Since studies of epiphyseal union have treated the ribs as a unit and more or less ignored the progress of union in the individual ribs, we feel there is a real need for further details on rib maturation.

3. Epiphyses of the Rib Heads.

Table 50 shows the percentages of cases with complete union for each age group. Although both right and left sides were observed, no significant difference in the progress of union for either side was found.

TABLE 50

RIB HEAD EPIPHYSES: AGE DISTRIBUTION OF THE PERCENTAGE OF COMPLETE UNION (Ribs)

Age	No.	1	2	3	4	5	6	7	8	9	10	11	12
17	10	-	-	-	-	-	-	-	-	-	-	-	-
18	45	40	24	17	15	15	11	13	15	20	22	22	38
19	52	41	30	25	19	17	17	11	13	15	21	30	36
20	45	64	55	52	46	46	31	28	28	31	38	53	60
21	37	78	73	70	64	67	64	54	51	62	67	73	78
22	25	96	92	86	80	84	84	72	72	80	86	92	92
23	27	96	96	96	92	92	92	92	92	92	96	96	96
24	14	100	100	100	100	100	100	100	100	100	100	100	100
Total	255												

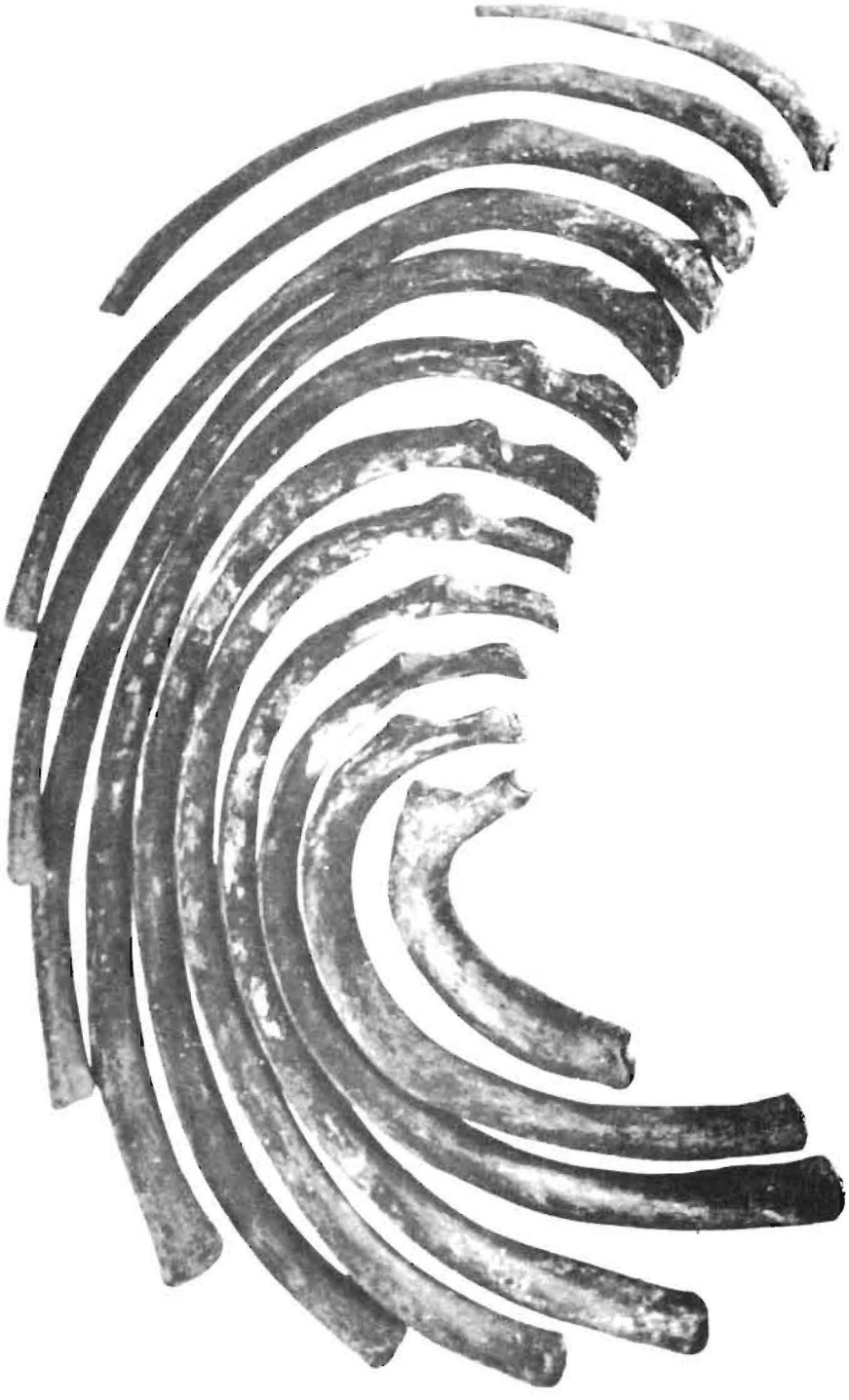

Fig. 83 Left ribs in anatomical order. Note that the head epiphyses of the middle ribs are in stage 1 of union. (No. 390, 18 years).

It is worthy of note that complete union has not occurred in any of the 10 cases constituting the 17 year age group. However, since the next age group shows percentages of union of as much as 40 percent, it is likely that a larger 17 year sample would reveal some instances of complete union.

It is interesting also that the ribs at both ends of the sequence mature more rapidly than those in the middle (also seen in Fig. 83). The epiphyses on the heads of the 4th to 9th ribs are particularly slow to unite. As has been shown in Chapter VI, a similar pattern of maturation characterizes the vertebrae. The ribs complete their maturation in the 23rd year.

The utility of any ageing criterion depends on the parts of the skeleton available. Though Stevenson questions the value of rib epiphyses as age indicators, they can be helpful in cases where age identification must rely on the ribs alone. However, since all rib epiphyses do not unite at the same time, but in a demonstrated sequence, age estimates must be qualified according to the particular ribs upon which the estimations are based.

4. Summary

The present data point to a probable age of 17 years for first appearance of complete union of the head epiphyses and a definite age of 24 years for the stage when all ribs are mature in all cases. However, ossification begins in the upper and lower ribs and slowly progresses toward the middle. Thus, the last ribs to become fully united are ribs 4 to 9.

CHAPTER XI

TOTAL PATTERN OF SKELETAL MATURATION

In the foregoing chapters we have concentrated on individual events in skeletal maturation without considering their interrelationship. It has been generally believed, however, that an estimation of age should be based on the maturational status of as many events as possible. Therefore, we need now to consider the total pattern of ossification as a possible tool for purposes of age identification.

With this in mind, we have attempted to formulate a mathematical expression of the major events in skeletal maturation that could, for any individual skeleton, be translated into a probable mean age.

The data were treated much the same as outlined in the section on the total pattern of suture closure, so that the maturational stage for each individual is represented by the sum of the scores for the over-all epiphyseal activity. Again, the standard scale of 0-4 was changed to 1-5. Also, since the total skeleton is not always available for epiphyseal scoring, we have computed regression equations for three skeletal segments as follows:

Segment I. Sutures:

Spheno-frontal	Lambdoid
Spheno-parietal	Coronal
Spheno-temporal	Sagittal
Squamous	Metopic
Masto-occipital	Basilar

Postcranial epiphyses

Humerus, proximal	Tibia, proximal
Humerus, distal	Tibia, distal
Humerus, medial epicondyle	Fibula, proximal
Radius, proximal	Fibula, distal
Radius, distal	Innominate, primary elements
Ulna, proximal	Iliac crest
Femur, head	Ischial ramus
Femur, gtr. trochanter	Clavicle, medial
Femur, lsr. trochanter	Vertebral centra
Femur, distal	Scapula, acromion

Postcranial epiphyses: (cont'd)

Scapula, inferior angle	Sacrum, S1 ring (sup.)
Sacrum, S1-2 joint	Sacrum, lat. joints
Sacrum, S2-3 joint	Sacrum, auricular epiphyses
Sacrum, S3-4 joint	Ribs, 1-4 and 9-12
Sacrum, S4-5 joint	Ribs, 5-8

Segment II. Includes all postcranial epiphyses listed for Segment I.

Segment III. Postcranial epiphyses:

Humerus, proximal	Femur, distal
Humerus, medial epicondyle	Iliac crest
Radius, distal	Clavicle, medial
Femur, head	Sacrum, 3-4 joint

Sacrum, lateral joints

Scatter diagrams, in which age is plotted against total maturation scores for the three segments, are represented in Figures 84, 85 and 86. As can be seen, the distribution indicates a curvilinear relationship but for simplicity, two straight line regressions were derived to fit the discrete segments of the curve. The age range and predicted age for the total scores in all three segments are shown in Table 51. The use of the two straight line regressions leads to minor differences in the predicted age columns for Segments II and III where the regressions are overlapped. However, the overlap is slight (not more than .19 of a year), and no significance should be attributed to these differences in age prediction.

Table 51 has not been carried beyond the 25th year because, with the exception of the metamorphosis of the pubic symphysis, ossification is essentially complete by that year. Those epiphyses that still show degrees of non-union at 25 linger on for several years and terminate erratically. There is further consideration that our samples for age groups above 25 years are too small to be representative. Thus, for information in the older ages, we can do no more than refer the reader to the foregoing chapters on individual maturational events (for example, Table 30 in Chapter V shows that the medial epiphyses of the clavicle are united in all cases by the 31st year).

To apply Table 51 to specific cases of age identification, we have constructed a scoring form (Figure 87) in which the maturational events are arranged in the order of their appearance in chapters 1-10. When the age of an unidentified skeleton is to be estimated, the observed status of

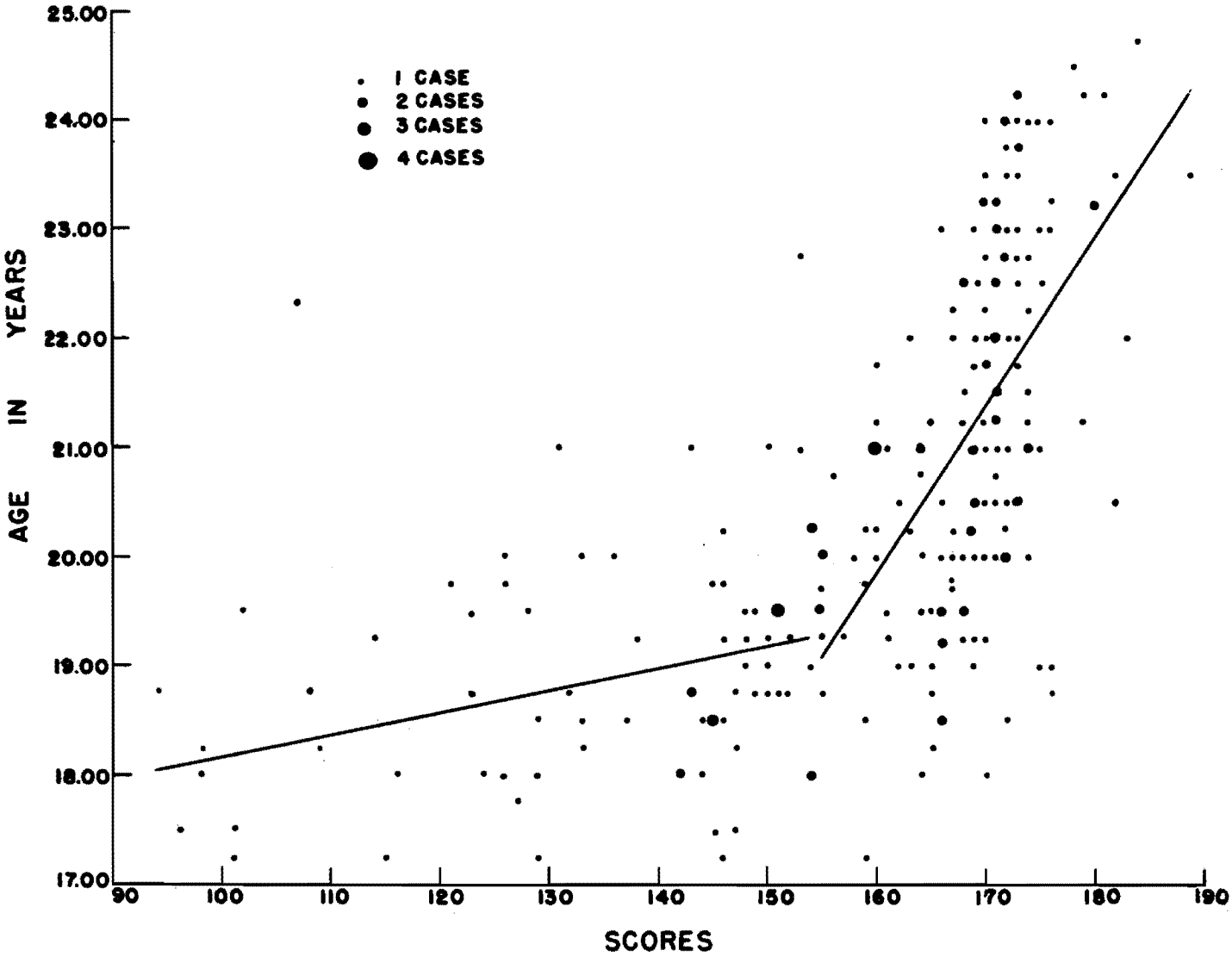

Fig. 84 Scatter diagram with regression lines showing relationship between Segment I scores and age.

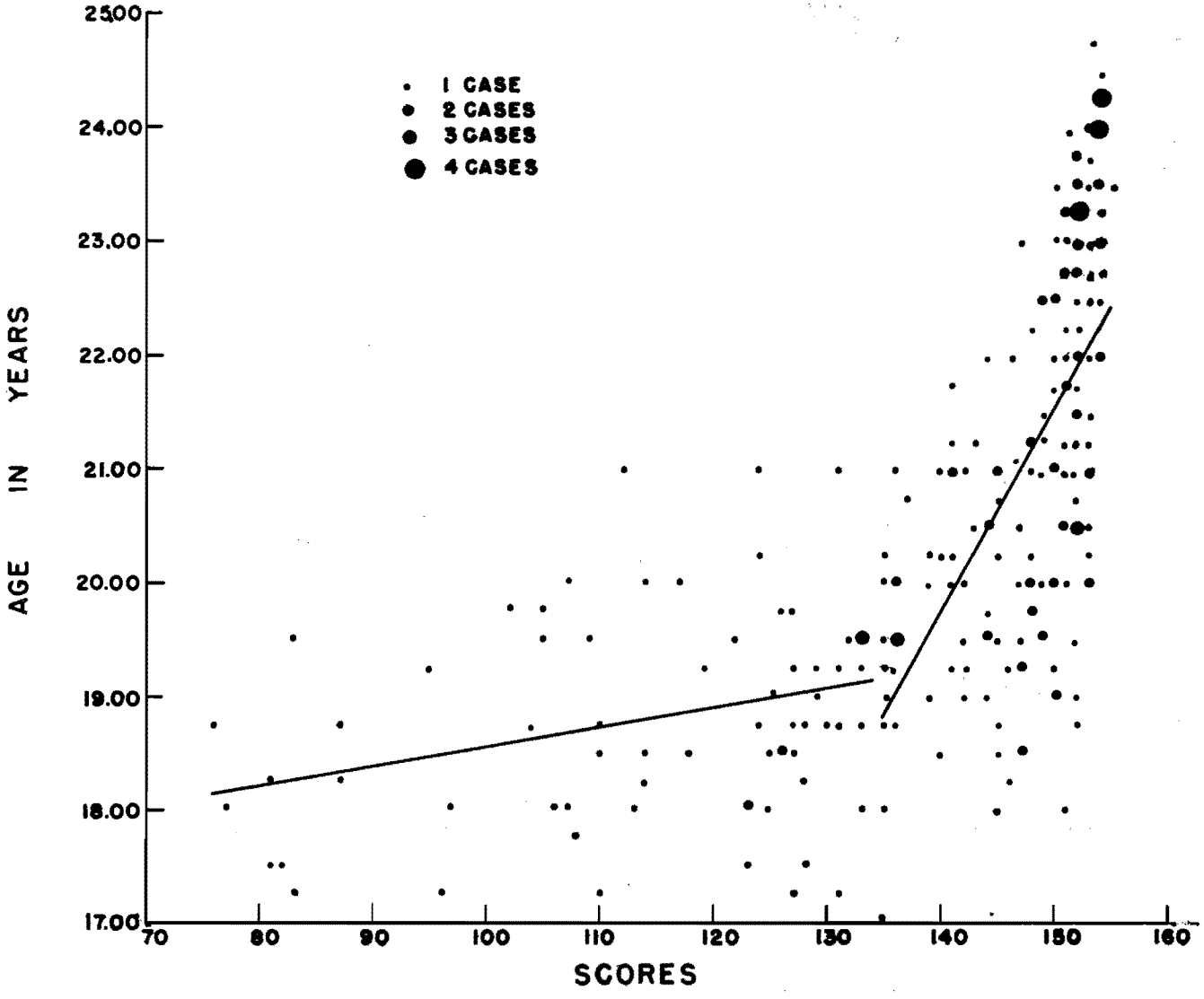

Fig. 85 Scatter diagram with regression lines showing relationship between Segment II scores and age.

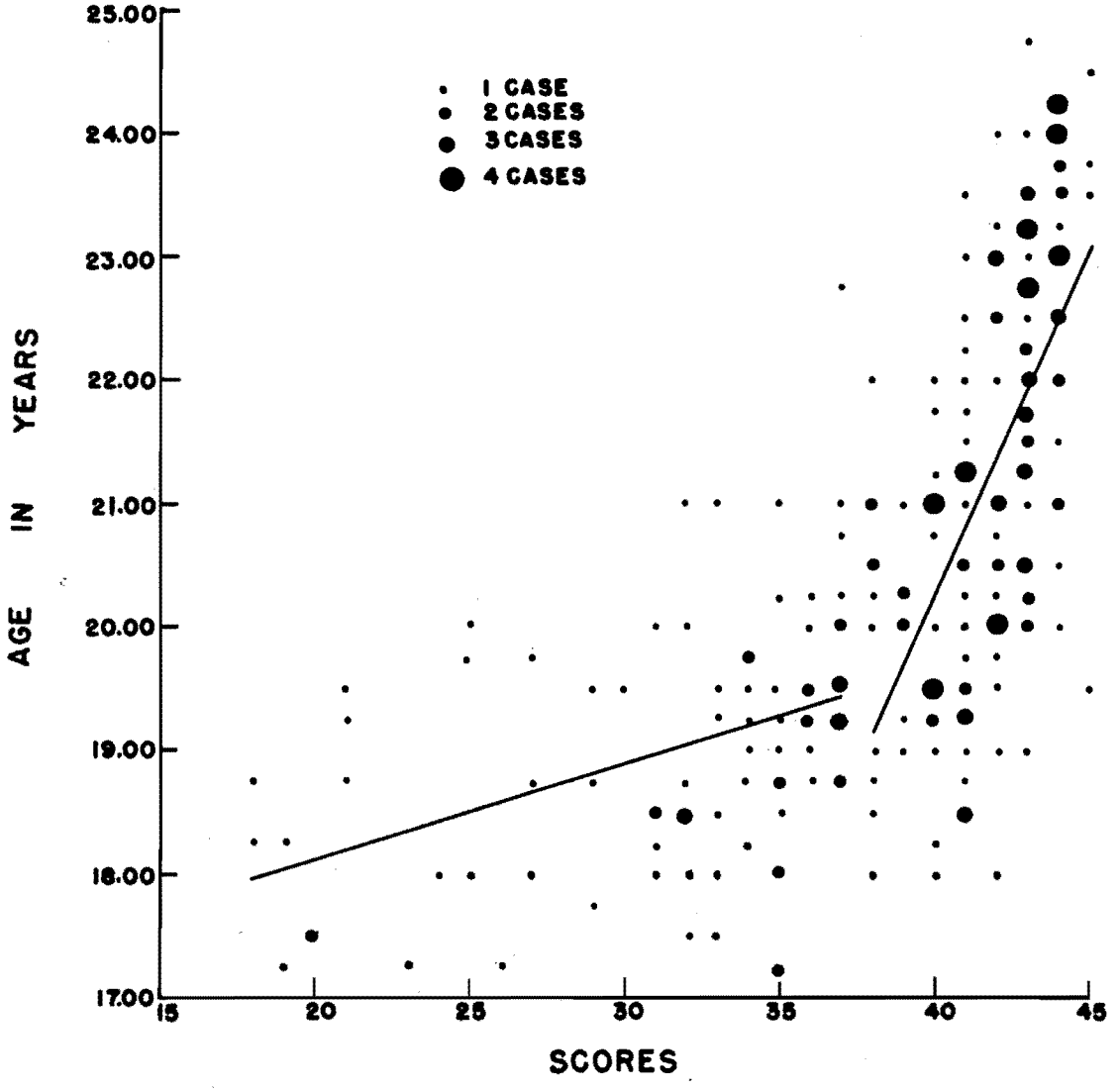

Fig. 86 Scatter diagram with regression lines showing relationship between Segment III scores and age.

TABLE 51

TOTAL MATURATIONAL SCORE FOR SKELETAL SEGMENTS I, II, AND III SHOWING AGE RANGE AND PREDICTED AGE BASED ON THE REGRESSION OF SEGMENTAL SCORES AND AGE.*

SEGMENT I			SEGMENT II			SEGMENT III		
Score	**Observed Age Range	Predicted Age	Score	Observed Age Range	Predicted Age	Score	Observed Age Range	Predicted Age
90	17-19	17.96	75	17-19	18.13	18	17-18	17.98
95	17-19	18.07	80	17-20	18.21	20	17-20	18.13
100	17-20	18.17	85	17-20	18.30	22	17-20	18.28
105	17-20	18.27	90	17-20	18.39	24	17-21	18.43
110	17-20	18.38	95	17-20	18.48	26	17-20	18.59
115	17-19	18.48	100	17-20	18.56	28	17-20	18.74
120	17-20	18.58	105	17-21	18.65	30	17-21	18.89
125	17-21	18.69	110	17-22	18.74	32	17-22	19.04
130	18-22	18.79	115	17-21	18.83	34	17-22	19.19
135	18-22	18.89	120	17-22	18.91	36	17-22	19.34
140	18-22	19.00	125	17-21	19.00			
145	18-21	19.10	130	17-23	19.09	38	18-23	19.15
150	18-23	19.21				40	18-24	20.27
			135	18-22	18.81	42	18-25	21.39
155	18-21	19.09	140	18-23	19.73	44	19-25	22.52
160	18-23	19.86	145	18-24	20.65	46	19-25	23.64
165	18-24	20.63	150	18-24	21.57			
170	18-25	21.40	155	19-25	22.49			
175	18-25	22.17						
180	20-25	22.93						
185	20-25	23.70						
190	21-25	24.47						

*Age prediction equations:

SEGMENT I

(Scores 90-150) Age = .0207 Score + 16.1003

(Scores 155-190) Age = .1537 Score + 4.7311

SEGMENT II

(Scores 75-130) Age = .0175 Score + 16.8140

(Scores 135-155) Age = .1842 Score + 6.0598

SEGMENT III

(Scores 18-36) Age = .0758 Score + 16.6146

(Scores 38-46) Age = .5617 Score + 2.1995

**Score intervals for Segments I, II, and III are in units 5, 5, and 2 respectively. To calculate for scores between intervals, the appropriate prediction equations are provided.

	Observed Score	Remarks
Sutures:*		
Spheno-frontal	_____	_____
Spheno-parietal	_____	_____
Spheno-temporal	_____	_____
Squamous	_____	_____
Masto-occipital	_____	_____
Lambdoid	_____	_____
Coronal	_____	_____
Sagittal	_____	_____
Metopic	_____	_____
Basilar	_____	_____
Postcranial Epiphyses:		
Humerus, prox.	_____	_____
Humerus, dist.	_____	_____
Humerus, med. epicondyle	_____	_____
Radius, prox.	_____	_____
Radius, dist.	_____	_____
Ulna, prox.	_____	_____
Ulna, dist.	_____	_____
Femur, head	_____	_____
Femur, gtr. troch.	_____	_____
Femur, lsr. troch.	_____	_____
Femur, dist.	_____	_____
Tibia, prox.	_____	_____
Tibia, dist.	_____	_____
Fibula, prox.	_____	_____
Fibula, dist.	_____	_____
Innominate, prim. el.	_____	_____
Iliac crest	_____	_____
Ischial ramus	_____	_____
Clavicle, medial	_____	_____
Vertebral centra	_____	_____
Scapula, acromion	_____	_____
Scapula, inf. angle	_____	_____
Sacrum, 1-2 joint	_____	_____
Sacrum, 2-3 joint	_____	_____
Sacrum, 3-4 joint	_____	_____
Sacrum, 4-5 joint	_____	_____
Sacrum, lat. joints	_____	_____
Sacrum, auricular	_____	_____
Ribs, 1-4 and 9-12	_____	_____
Ribs, 5-8	_____	_____

Total Score _____ Estimated Age _____

Pubic Symphysis:		
Component I	_____	_____
Component II	_____	_____
Component III	_____	_____

Total Score _____ Estimated Age _____

All events scored on scale of 1-5: 1 = no closure; 2 = one quarter closed; 3 = one half closed; 4 = three quarters closed; 5 = complete closure.

*Sutures treated as complete units.

Fig. 87 Score sheet for the age identification of unknown remains.

each maturational event is entered on the form in the space provided. When the form is completed, the scores are then added, and their sum can be translated into 2 predicted ages by referring to the regressed values in Table 51. Thus, if an individual score was found to be 120 for Segment I, the individual case could be anywhere from 17-20 years, but has the high probability of having the predicted age of 18.58 years. The age prediction equations for each segment are footnoted to Table 51. Also, a separate space has been provided on the scoring form for the purpose of entering clarifying or additional information for individual events. In interpreting such data, it may be necessary to refer to the more detailed analyses in the preceding chapters before completing the analysis.

Obviously the three segments we have outlined do not cover all the possible combinations of maturational events. Thus, to aid in the estimation of age from skeletal remains that are too deficient in maturation areas to fulfill the required number of events for any of the three segments, we have arranged the complicated data of epiphyseal activity in a more subjective manner (Table 52). This has amounted to emphasizing the cases showing minimum and maximum maturation at all age levels. In other words, we have subjectively selected a few cases in each age group representing the least and most mature individuals.

In Table 52, the selected extreme cases are arranged chronologically and in the order of completion of the component maturational events. The table thus clearly shows not only the order of maturational progression from 17 to 25 years, but also the extreme variability of skeletal maturation for each age group. Inspection of the different age groups shows individuals who are older, chronologically, but least mature, osteologically. The reverse is also true. This chronological over-lap further emphasizes the fact that the full range of variability for current populations must be known before reliable methods for estimating skeletal age can be formulated.

The first column in Table 52 includes 50 epiphyses and 1 suture (basilar) beginning with the first area to show complete union for all cases (distal end of humerus) and ending with the last epiphysis to unite in all cases (sacrum, S1-2 joint).* As one follows an event across the chart from left to right, the age at which maturation is reached is indicated by the occurrence of stage 4 for all cases and the discontinuance of scores from that age on.

*Since the basilar suture has proved itself a most reliable ageing criterion, we have included it with the epiphyseal data in Table 52.

TABLE 52

EXAMPLES OF LEAST AND MOST MATURE INDIVIDUALS FOR EACH AGE GROUP SHOWING THE INDIVIDUAL MATURATIONAL SCORES LISTED IN CHRONOLOGICAL ORDER.

Age group	17 years		18 years		19 years		20 years		21 years		22 years		23 years		24 years		25 years	
Size of sample from which cases were selected.	10		45		52		45		37		24		26		14		13	
Serial number	425 96 210	50 381 99	44 72 30	51 10 298	2 289 264	165 146 292	93 73 233	41 65 83	305 151 152	252 190 144	213 432 229	330 80 271	245 29 85	167 279 145	21 225 231	234 276 37	380 111 176	170 140 196
Individual age (years, months & days)	17-6-21 17-8-2 17-9-9	17-7-3 17-9-0 17-10-10	18-0-18 18-5-24 18-11-18	18-9-17 18-9-27 18-11-23	19-5-4 19-7-23 19-11-19	19-1-1 19-5-3 19-10-1	20-0-28 20-0-14 20-6-22	20-6-10 20-7-26 20-10-25	21-0-2 21-0-24 21-1-0	21-4-8 21-9-17 21-10-19	22-0-10 22-7-12 22-11-10	22-1-5 22-2-26 22-5-0	23-1-10 23-1-18 23-3-6	23-2-9 23-3-2 23-3-8	24-0-8 24-2-23 24-3-0	24-6-3 24-9-16 24-11-5	25-5-25 25-7-25 25-10-9	25-2-29 25-6-18 25-11-3
	least mature	most mature	least mature	most mature	least mature	most mature	least mature	most mature	least mature	most mature	least mature	most mature	least mature	most mature	least mature	most mature	least mature	most mature
Humerus, distal end	4 / 4	4 4 4	4 4 4	4 4 4														
Innominate, primary elements	3 3 3	4 4 4	4 4 4	4 4 4														
Ulna, proximal end	4 4 4	4 4 4	4 4 3	4 4 4	4 4 4	4 4 4												
Radius, proximal end	3 3 3	4 4 4	4 4 3	4 4 4	4 4 4	4 4 4												
Tibia, distal end	4 4 3	4 4 4	2 0 2	4 4 4	4 2 4	4 4 4	4 4 4	4 4 4										
Humerus, medial epicondyle	3 1 3	4 4 4	2 0 2	4 4 4	4 3 4	4 4 4	4 4 4	4 4 4										
Fibula, distal end	3 4 0	3 4 4	1 3 0	4 4 4	2 2 4	4 4 4	4 4 4	4 4 4										
Femur, head	3 2 3	4 4 4	1 3 2	4 4 4	3 3 4	4 4 4	4 4 4	4 4 4										
Femur, gtr. trochanter	3 2 2	4 4 4	1 2 2	4 4 4	4 2 4	4 4 4	4 4 4	4 4 4										
Femur, lsr. trochanter	3 2 0	4 4 4	0 2 2	4 4 4	4 2 4	4 4 4	4 4 4	4 4 4										
Basilar suture	3 0 4	4 3 3	2 3 3	4 4 4	4 4 4	4 4 4	4 3 4	4 4 4	4 4 4	4 4 4								
Femur, distal end	0 0 0	4 4 4	0 0 0	4 4 4	4 0 3	4 4 4	3 3 3	4 4 4	3 3 3	4 4 4	4 4 4	4 4 4						
Fibula, proximal end	0 0 0	4 4 3	0 0 0	4 4 4	4 0 2	4 4 4	4 2 4	4 4 4	4 3 3	4 4 4	4 4 4	4 4 4						
Sacrum, epiphyseal ring, S1	0 0 0	3 3 3	/ 0 0	3 4 4	0 0 1	4 4 4	3 2 3	4 4 4	3 2 1	4 4 4	4 4 4	4 4 4						
Sacrum, lateral joints	2 1 3	3 4 4	/ 3 2	3 4 4	2 3 3	4 4 4	3 3 3	4 4 4	3 3 3	4 4 4	4 4 4	4 4 4						
Sacrum, auricular epiphysis	0 0 0	3 3 3	/ 0 0	4 4 4	0 2 2	4 4 4	3 23	4 4 4	3 3 2	4 4 4	4 4 4	4 4 4						
Tibia, proximal end	2 0 1	4 4 4	0 0 0	4 4 4	2 0 3	4 4 4	4 3 4	4 4 4	4 3 3	4 4 4	4 3 4	4 4 4	4 4 4	4 4 4				
Iliac crest	0 0 0	3 3 3	0 0 0	4 4 4	0 0 0	4 3 4	1 1 1	4 4 4	1 1 3	4 4 4	3 4 4	4 4 4	4 4 4	4 4 4				
Ulna, distal end	0 0 0	3 4 4	0 0 0	4 4 4	0 0 2	4 4 4	1 0 0	4 4 4	3 3 3	4 4 4	3 3 3	4 4 4	4 4 4	4 4 4				
Radius, distal end	0 0 0	3 3 3	0 0 0	4 4 4	0 0 2	4 4 4	2 0 0	4 4 4	2 3 3	4 4 4	3 3 3	4 4 4	4 4 4	4 4 4				
Scapula, acromion	0 0 0	4 4 4	0 0 0	4 4 4	2 0 3	4 4 4	0 2 0	4 4 4	4 3 3	4 4 4	4 4 0	4 4 4	4 4 4	4 4 4				
Scapula, inferior angle	0 0 0	4 4 4	0 0 0	4 4 4	0 0 0	3 4 4	0 0 0	4 4 4	0 3 0	4 4 4	4 4 2	4 4 4	4 4 4	4 4 4				
Scapula, medial border	0 0 0	4 4 4	0 0 0	4 4 4	0 0 0	/ 4 /	0 0 0	4 4 4	/ / 1	4 4 4	2 4 1	4 4 4	4 4 4	4 4 4				
Spines, vertebral	0 0 0	4 4 4	/ 0 /	4 4 4	0 0 1	4 4 4	0 0 1	4 4 4	3 / 2	4 4 4	3 4 1	4 4 4	4 4 4	4 4 4				
Sacrum, S4-5 joint	3 / 3	3 3 3	/ 3 3	/ 4 4	3 3 /	4 4 4	3 3 3	4 4 4	3 3 3	4 4 4	/ 4 3	4 4 4	4 4 4	4 4 4				
Sacrum, S3-4 joint	2 0 3	3 3 3	/ 2 2	3 4 4	2 2 3	4 4 4	3 3 3	4 4 4	3 3 3	4 4 4	/ 4 3	4 4 4	4 4 4	4 4 4				
Ischial tuberosity	1 0 1	3 2 3	1 / 0	4 4 4	4 1 3	4 4 4	3 4 3	4 4 4	3 4 3	4 4 4	3 4 4	4 4 4	4 4 4	4 4 4				
Sternum, clavicular notch	2 2 2	3 3 3	3 3 1	4 3 /	2 / 2	4 / 4	3 2 2	4 4 4	3 4 4	4 4 4	/ 4 2	4 4 /	4 4 4	4 4 4				
Humerus, proximal end	0 0 1	3 3 3	0 0 0	4 4 4	0 0 2	4 3 4	2 0 1	4 4 4	2 3 3	4 4 4	3 3 3	4 4 4	3 4 4	4 4 4	4 4 4	4 4 4		
Ribs, 1-4 and 9-12	0 0 0	2 2 3	0 0 0	4 4 4	0 0 0	4 4 /	0 / 0	4 / 4	1 1 1	4 4 4	4 4 2	4 4 4	4 2 3	4 4 4	4 4 4	4 4 4		
Ribs, 5-8	0 0 0	2 2 2	0 0 0	4 4 4	0 0 0	4 4 /	0 / 0	4 / 4	0 0 0	4 4 4	1 3 0	4 4 4	4 2 3	4 4 4	4 4 4	4 4 4		
Vertebral column, superior epiphyseal rings (thoracic)	1 0 0	2 3 3	/ 0 /	4 4 4	1 1 0	4 4 4	2 2 2	4 4 3	2 1 2	4 4 3	3 4 3	4 4 4	3 4 3	4 4 4	4 4 4	4 4 4		
Sacrum, S2-3 joint	2 2 3	3 3 3	2 2 2	3 3 4	2 2 3	4 4 4	3 3 2	4 4 4	4 3 2	4 4 4	/ 3 3	4 4 3	3 4 4	4 4 4	4 4 4	4 4 4		
Ischial ramus	0 0 0	3 2 3	0 0 0	4 4 4	1 0 0	4 4 4	0 1 0	4 4 4	0 4 0	4 4 4	3 4 0	4 4 4	4 2 3	4 4 4	4 4 4	4 4 4		
Sternum, costal I notch	1 1 1	2 2 3	1 1 0	/ 2 /	1 / 1	1 / /	/ / 1	4 4 /	/ / 1	4 4 4	/ 4 1	4 / /	4 4 2	4 4 4	3 / 2	4 4 3	4 4 4	4 4 4
Clavicle, medial epiphysis	0 0 0	0 0 0	0 0 0	1 0 2	0 0 0	1 2 3	0 0 0	2 1 1	0 1 0	2 3 2	0 1 0	3 2 2	0 1 1	3 / 3	2 3 1	3 4 2	2 4 2	3 4 4
Sacrum, S1-2 joint	3 0 3	3 3 3	1 2 2	3 3 3	2 1 3	4 3 3	2 2 2	4 4 4	4 2 2	4 4 4	3 3 3	4 3 3	3 3 4	4 3 4	4 4 3	4 3 4	3 3 3	4 4 4

When the age of fragmentary remains is to be estimated, the observed status (by the standard scoring method of 0-4) of as many maturational events as possible should be listed in an order similar to that shown in Table 52. When these observations have been completed they may be compared directly to the chronological list in Table 52 and, by moving the prepared column of observed scores from one age to another, it can be related to the most applicable column of sample scores. Of course, the reliability of this system depends largely on the number of observed events that can be used. Ageing estimates based on single events may best be analyzed by referring to the chapter of this paper which is concerned with that particular event.

Inspection of the age ranges for the total score groups in Table 51 and for the selected extreme cases in Table 52 clearly shows the high variability of skeletal maturation. For several years, around the end of the second decade of life, many maturational events are occurring simultaneously in the individual. Also, in each age group, we are dealing with cases of retarded maturation on the one hand and with cases of accelerated maturation on the other. However, nothing has been said so far about the causes of this variable rate of maturation. Todd (1935) and others have emphasized the effect on the growing individual of cultural factors centering mainly in the fields of health and nutrition. They claim that retarded growth is more common among the less-favored economic groups and accelerated growth is characteristic of the well-to-do classes. Our records do not include data on social status, except as it may be reflected in race.

As we pointed out on page 11, the present sample includes 35 American Negroes. Of the 20 most retarded and 20 most accelerated cases in age groups 17-25, the retarded cases comprise 15 Caucasoids and 5 Negroids, whereas the accelerated cases comprise 19 Caucasoids and 1 Negroid. The retarded Negroids are distributed as follows: 2 at 17-18, 1 at 20 and 2 at 25 years. Although 5 is not a large number, in this instance it represents 14.3 percent of the total Negroids in our series. By contrast, the 15 retarded Caucasoids represent only 4.4 percent of the total Caucasoids in our sample. On the other hand, the 1 accelerated Negroid and 19 accelerated Caucasoids represent 2.8 and 5.6 percent of their respective samples. From this meager evidence it would seem that cultural factors may have affected the present sample, or that genetic differences may cause retardation.

At the time our sample was assembled, all cases selected were unknowns. Even though the presence of retarded individuals was suspected, due to various factors, we made no effort to eliminate them. We feel that this procedure was justified, because in the actual work of age identification there is no way of knowing the sociological status of unknowns and hence any method used to derive age estimates must include all possibilities.

As a result of the experience gained in constructing Tables 51 and 52, we are now able to distinguish certain critical areas, or those areas that, if possible, should be observed first as the best indicators of skeletal age. By giving first attention to these critical areas, the observer can make a rapid appraisal of the age status of the skeleton in question and thus learn his subsequent course for final age analysis. Actually, Segment III (refer to tabulation, beginning of this chapter) is comprised of 9 of the most critical epiphyses.

We suggest that the innominate bone is the most critical ageing area of the skeleton. The combination of pubic symphysis, iliac crest, ischial tuberosity and ramus will immediately place the skeleton in its proper age group. If the pubic symphysis, which is a good age indicator over much of the life span, is damaged or missing, the remaining age areas of the innominate will give the observer a clue as to his next most reliable source of age information. For example, if the iliac crest suggests an adolescent age, then the basilar suture and the epiphyses of the elbow can be turned to for both clarification and supportive evidence. On the other hand, if the iliac crest exhibits the pattern of a young adult, the epiphyses of the shoulder, wrist and knee joints as well as the medial end of the clavicle will help to establish an exact age estimate.

CONCLUDING STATEMENT

One of the principal conclusions emerging from the foregoing study is that individual maturational features or events are highly variable in the chronological sense. An epiphysis, for instance, which is completely closed in 100% of the population only after the 24th year, can have reached this stage for the majority of individuals several years earlier. It is incorrect and misleading, therefore, to state categorically, as has been done all too often in the past, that this epiphysis closes, let us say, at 21 years, or even at 20.5-21.5 years. We feel that the present documentation of full variability and the emphasis we have placed thereon is a step forward in identification procedure.

We also point out that, although variability in individual maturational features leads to variability in the total pattern of maturation, it is usually less, again in the chronological sense. Viewing an unknown individual as a total skeleton, rather than bone by bone, it is possible thus to estimate the age at death within narrower limits. We have seen that the anthropologists who first examined the material on which this study is based, and who judged the skeleton as a whole, succeeded in giving remarkably good estimates of age. Their errors, it is now clear, were due to reliance on existing standards which do not allow for variability.

There is no denying the fact that a remarkable orderliness exists in the progress of maturation; that in the case of the epiphyses, closure takes place in a surprisingly uniform sequence, and especially when age is disregarded. We have laid very little stress on this fact since it is already well established and is of secondary importance in age identification. Nevertheless, the establishment of this principle was an important advance in our knowledge of ageing.

The skeletons used in previous studies on ageing were derived mostly from dissecting rooms, which are the repositories of the unclaimed dead of our large cities. In many cases the individuals had died in hospitals of lingering illnesses. But the fact that they were not claimed by families carries implications of irregular living and low social status. Under the circumstances it is understandable that the scientists studying age changes in these skeletons were prone to be suspicious of the normality of individual cases. Not infrequently, as we have pointed out, they eliminated cases that varied widely from their concepts of normal maturation. However it should be remembered that the goal of these investigators was the establishment of broad principles of maturation, not the collection of data for application to problems of age identification. In retrospect we can see clearly that variability is present in the skeletons which they studied,

but almost wholly disregarded in the principles they enunciated.

By contrast with the doubtful physical status of the dissecting-room population which provided existing ageing standards, the military population used in the present study can only be considered more typical and normal. Soldiers are selected for physical fitness and trained for endurance; they are well cared for, medically and nutritionally. Never before has there been an opportunity to study ageing on such fine physical specimens. Here, then, the elimination of cases on account of variability in maturation would amount to scientific dishonesty. One might even expect that the variability encountered in the military sample is less than in the unselected, less evenly healthy, general population.

No case has been eliminated from the present series on the basis of supposed abnormality. Moreover, we have included POW's who were subjected to malnutrition for many months. In some of these POW's, undoubtedly, the malnutrition was accentuated by dysentery and other debilitating conditions. Yet we feel that any resulting maturational disturbances are within the limits of the general population. Certainly their inclusion does not appreciably detract from the validity of the results obtained.

Our concern with the problem of variability in maturation stems, of course, from the very nature of human identification. As a rule the identification specialist has no way of knowing what was the racial, sociological or health status of the individual he is dealing with. Any or all of these factors could have affected (accelerated or retarded) the unknown's rate of growth. All that the specialist can predict with safety is the age range in which the observed complex of maturational features are known to occur. If he attempts to place the individual in a particular spot in the age range, he is only guessing. The present evidence of variability should make the specialist more cautious.

Finally, we would point out that our insistence on chronological variability in maturation is derived ultimately from the impressive sample we were privileged to study. Where, in one of the few comparable studies, Stevenson (1924) had only 10 individuals (3 of them females) at the critical age of 18, we have 45; where he had only 6 at the age of 21, we have 39; and so on. Although it is distressing to consider the extent of the loss of American youth implied in these figures, we are consoled in part by being able to perpetuate them in the form of knowledge. At the same time, we hope that our efforts will not discourage others from continuing in this area of investigation. Certainly there is an immediate need for additional research in the younger and older age groups.

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