

CRANIAL SUTURE CLOSURE

ITS PROGRESS AND AGE RELATIONSHIP

PART III.—ENDOCRANIAL CLOSURE IN ADULT MALES OF NEGRO STOCK

T. WINGATE TODD AND D. W. LYON, JR.

Hamann Museum, Department of Anatomy, Western Reserve University.

CONTENTS

INTRODUCTION.....	47
MATERIAL AND METHOD.....	48
SUTURES OF THE VAULT.....	49
1. THE SAGITTAL SUTURE.....	49
2. THE CORONAL SUTURE.....	53
3. THE LAMBDOID SUTURE.....	56
THE NEGRO DISCARDS.....	57
THE CIRCUM-MEATAL SUTURES.....	59
1. THE MASTO-OCCIPITAL SUTURE.....	59
2. THE SPHENO-TEMPORAL SUTURE.....	61
3. THE SQUAMOUS SUTURE.....	62
4. THE PARIETO-MASTOID SUTURE.....	63
THE ACCESSORY SUTURES.....	63
1. THE SPHENO-PARIETAL SUTURE.....	63
2. THE SPHENO-FRONTAL SUTURE.....	63
COMPARISON OF WHITE AND NEGRO CLOSURE.....	65
LAPSED UNION IN NEGROES AND WHITES.....	69
SUMMARY.....	70
REFERENCES.....	71

INTRODUCTION

In our two former papers (2, 3) we have given a description of suture closure in adult males of White Stock and we have discussed the observations of previous workers in the light of our findings. As a result we have felt compelled to reject most earlier conclusions upon the subject and set forth a new scheme of closure based upon age relationship, discarding absolutely the current theory of closure tendency. There will be no necessity to review these facts afresh but it is imperative to obtain some information of the effect of Race, or rather of human Stock upon suture closure. For this purpose we require a collection of skulls of known age, bisected so that the interior may be studied with ease, belonging to another type of humanity. We have made careful inquiry among other Institutions for a collection of such a character but without success and have been driven back upon our own collection of Negro males. Now it is popularly supposed that the American Negro is so thoroughly hybridized as to be ineligible as a representative of true Negro Stock. We do not at all agree with this assumption for our considerable experience of the skeletons of these people convince us that there are very few features which can be attributed to the influence of a

mixed White ancestry. It is not possible in this paper to give the evidence upon which this view is based but on another occasion we hope to set forth all the facts at our disposal. It will be significant however to study suture closure in the American Negro in order to ascertain what features are present in that type of people for comparison with those of White Stock. We shall therefore immediately lay down the results of our investigation, first of American Negro endocranial closure and afterwards of ectocranial closure.

MATERIAL AND METHOD

The skulls of known age utilized for the endocranial survey number 120. However 41 of these were discarded by the same tests used for the White males, leaving only 79 for the actual graph building. With so small a number we should not feel justified in proceeding were it not for two important facts. Since 1921 when this research was planned many skulls of known age have been added to the collection and although these do not enter into the graphs they confirm in every way the conclusions drawn therefrom. Secondly we have the large series of White males from which it has been possible to construct a scheme of closure progress constituting a standard whereby the Negro closure may be judged. Thus the deficiency in number is to a large extent made good.

Since there is nothing new in the method of rejection of abnormal Negro skulls we shall not dwell upon it but merely remark that whereas it was necessary to reject 13.0 per cent of White male crania we have found that we had to discard 34.2 per cent of the Negroes. At first sight this might seem significant evidence of hybridization. Unfortunately for such a view the finished graphs exhibit essentially the same features as the White graphs. Hence one would be logically compelled to hold that only some 30.0 per cent of American Negroes could be of pure blood. But rejection in this series is mostly on account of delayed union in some part or other of the suture complex, and the majority of the White discards were rejected for the same reason. Consequently it is evident that the modal closure pattern is in general the same for Negroes as for Whites but individual variability is more characteristic of the Negro. One cannot too strongly insist upon the importance of this conclusion the grounds for which will become apparent as we proceed.

The reader should recall that we subdivide cranial sutures into three groups. The sagittal, coronal and lambdoid constitute the sutures of the vault; the spheno-frontal and spheno-parietal are the accessory group; the remaining sutures form the circum-meatal group.

SUTURES OF THE VAULT

1. THE SAGITTAL SUTURE (Figs. 1 and 2)

The moving average of endocranial sagittal closure in the Negroes (Fig. 1) shows a much more uniform curve than that of the Whites. The salient features however are the same. Commencement of closure occurs at twenty-two and continues slowly until twenty-six when it has reached practically the same point as in the Whites. Thence-forward the curve becomes steeper and by thirty-one years closure is completed. In the male Whites closure was practically complete at this age although the terminal phase of closure was somewhat protracted.

Following the scheme initiated for the male Whites we may tabulate the results in the ensuing manner:—

Male Negro endocranial sagittal closure.

Closure commences at twenty-two with

- (a) a gradual rise to 1.0 at age twenty-six, followed by
- (b) a sharper steady rise to
- (c) complete closure at thirty-one years.

The skull tabulation is the following:—

Age	Period	Number of skulls	
		Retained	Rejected
17-21	pre-(a)	8	2
22-25	(a)	15	6
26-30	(b)	12	8
31-76	(c)	44	25
Total retained in series.....			79
Total rejected.....			41
Grand total.....			120
Percentage of discards to grand total.....			34.2
Percentage of discards (a)-(b) inclusive on total of these periods.....			34.1

Now let us examine the discards of thirty years and under. No. 693, age 18, shows complete closure of all the sagittal suture endocranially except the bregmatic part which is only one quarter united; closure of the middle part of each coronal, and of the lambdoid part of each lambdoid together with the middle part of the right lambdoid. The asteric part of the right lambdoid is half united. There is no closure at all in the bregmatic part of each coronal, in the pteric part of the left coronal and in the asteric part of the left lambdoid. The pteric part of the right coronal is one quarter united. The middle part of the left lambdoid is three-quarters closed. This condition of suture closure is clearly anomalous when we see that in no other instance of the remaining nine crania of less than twenty-two is there any closure at all. Beyond some slight acceleration the symphysis pubis shows no unusual characters. Acceleration of differentiation to about twenty years is indeed apparent all over

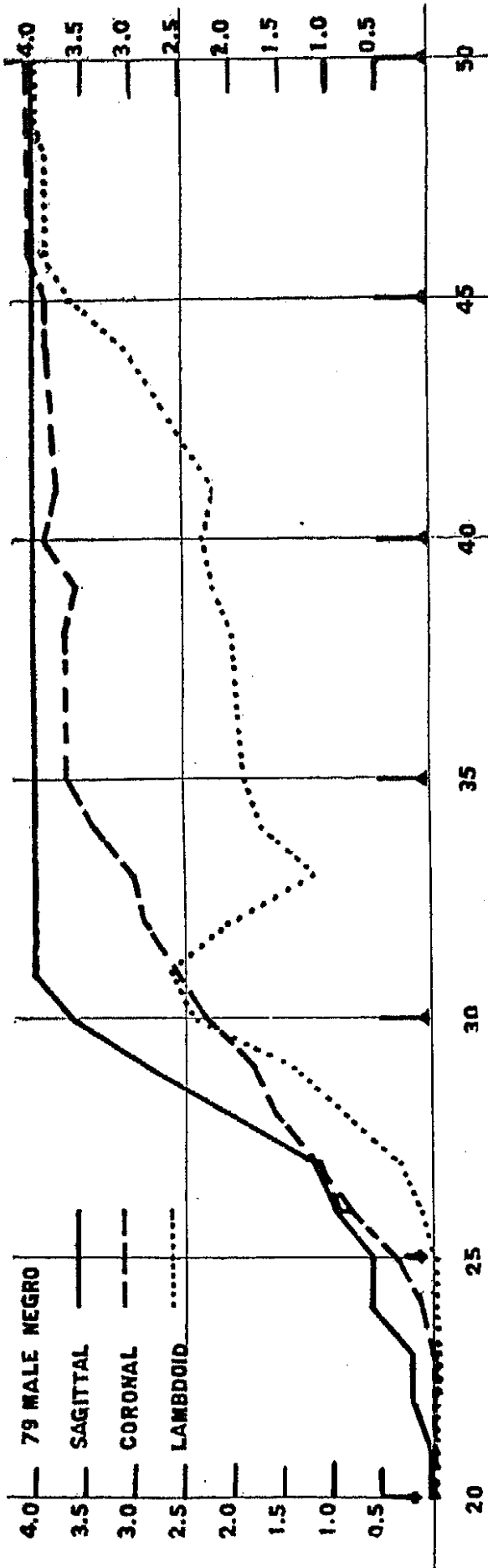


FIG. 1. Graph of closure in the vault sutures to illustrate the order of closure. All parts of the suture are averaged in this graph.

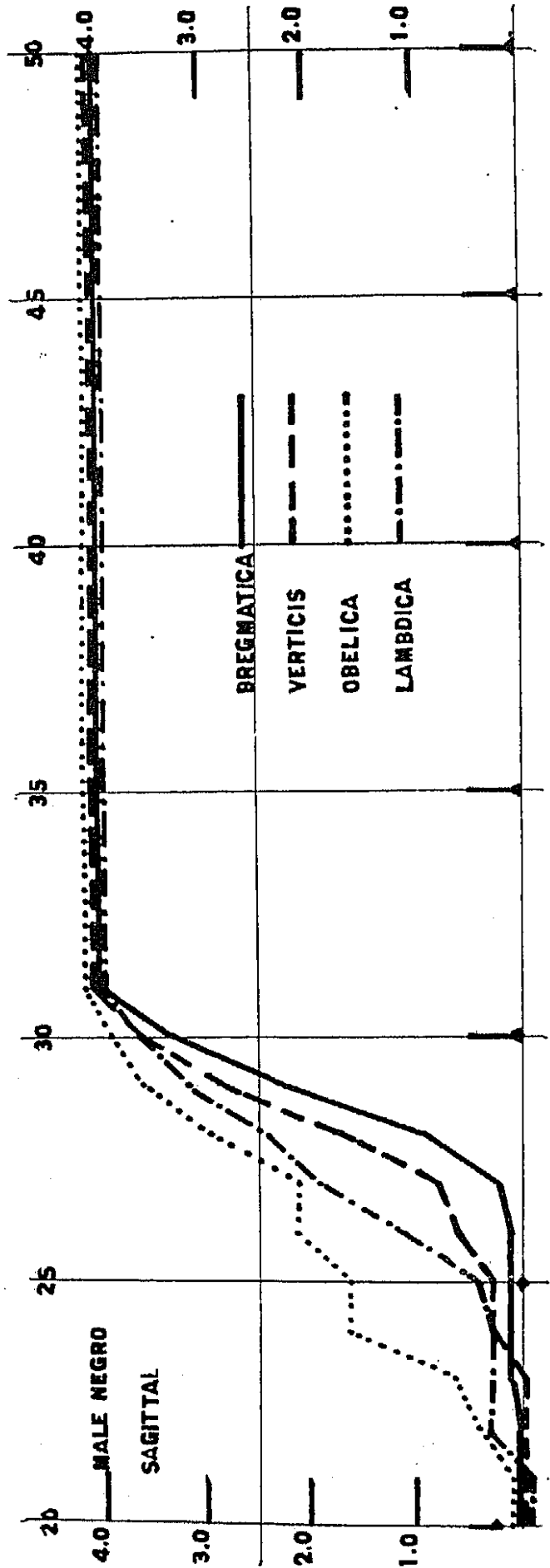


FIG. 2. Endocranial closure progress in the sagittal suture. The apparently more ordered closure in the several parts of the suture, when compared with the White graph, has probably no significance.

the skeleton but there is nothing comparable with the pronounced acceleration in cranial suture closure. It is entirely upon the state of the sutures that this skull has been eliminated from the series.

Nos. 525 and 744 of age twenty-two; 860 of age twenty-three; 764 of age twenty-five; and 190 of age twenty-six are all very beautiful examples of the anthropoid symphysial strain (4). There is complete fusion of the sagittal suture endocranially in all parts of each skull except No. 525, the bregmatic part of which is completely patent and the lambdoid only three-quarters closed.

The three specimens next to receive attention can be considered together. They are Nos. 379, age twenty-seven; 474, age twenty-eight; and 402, age twenty-nine. None shows any endocranial closure of sagittal, coronal or lambdoid sutures. All present the regressive form of symphysis and are retarded examples. How far one may associate the retardation in suture closure with the retardation of symphysial differentiation we cannot say at the moment.

There are four specimens the symphysis of which belongs to the intermediate group which I have shown to be a retrogressive and retarded form of the anthropoid strain. These are Nos. 716 and 802 of age twenty-eight; No. 563 of age twenty-nine; and No. 598 of age thirty. In No. 716 all the three sutures are completely closed. None of the others show any endocranial closure of sagittal, coronal or lambdoid sutures except No. 598 in which the second part of the left coronal is about one-quarter united. The explanation of the pronounced retardation of cranial differentiation in these specimens is not clear as yet.

The ten skulls in which there is more or less union of sutures can be arranged to exhibit their condition at a glance:—

TABLE I. PRECOCIOUS DISCARDS.

			R. 041	R. 442
Age 18.	No. 693.	Sagittal 1444; Coronal	; Lambdoid	
			L. 040	L. 430
			R. 000	R. 444
	No. 695.	Sagittal 0000; Coronal	; Lambdoid	
			L. 000	L. 000
			R. 344	R. 000
Age 22.	No. 366.	Sagittal 0444; Coronal	; Lambdoid	
			L. 344	L. 000
			R. 311	R. 020
	No. 525.	Sagittal 0443; Coronal	; Lambdoid	
			L. 121	L. 120
			R. 320	R. 000
	No. 744.	Sagittal 4444; Coronal	; Lambdoid	
			L. 320	L. 000
			R. 034	R. 144
	No. 765.	Sagittal 4444; Coronal	; Lambdoid	
			L. 000	L. 133

Age 23.	No. 860.	Sagittal 4444; Coronal	R. 000	; Lambdoid	R. 444
			L. 000		L. 444
			R. 330		R. 110
Age 25.	No. 764.	Sagittal 4444; Coronal	L. 130	; Lambdoid	L. 331
			R. 443		R. 443
Age 26.	No. 190.	Sagittal 4444; Coronal	L. 444	; Lambdoid	L. 444
			R. 444		R. 444
Age 27.	No. 716.	Sagittal 4444; Coronal	L. 444	; Lambdoid	L. 444

Three skulls only remain for consideration. Of these Nos. 366 and 765 are both of age twenty-two. In the former symphysial differentiation is accelerated slightly but by no means to such an extent as is cranial suture closure: in the latter there is actual retardation of symphysial differentiation by about three years. Like certain of the male White skulls these present an interesting problem for future solution. In both specimens the sagittal is completely closed endocranially. There are however certain irregular features in the closure of other cranial sutures which lead us to suspect that aberrant influence is at work confusing the regular and normal sequence of union.

No. 695, of age eighteen, shows a curious anomaly in complete fusion of the right lambdoid suture alone.

There seems to be some delay in commencement of closure of the bregmatic part of the suture when compared with the male Whites for it does not really begin to unite until twenty-seven, a matter of five years after closure commences in the White series. The obelica and the lambdae are quite comparable with the White series for they commence together to unite at twenty-two. Until twenty-five they continue slowly to fuse and then take on a more rapid rate, complete union occurring at thirty-one years. The pars verticis has a fairly uniform rise once it starts but the bregmatic part lags behind until twenty-seven after which its curve shoots up to the point of complete closure more rapidly than that of any of the others.

As with the male Whites many crania occur in which there is lapsed union of the vertex and more frequently of the lambdoid parts of the sagittal suture on the endocranial surface. The characteristic heaping up of bone along the suture margins picks these out immediately.

The smoother character of the Negro curve when compared with that of the Whites is undoubtedly due to the fact that we had already got a grip upon the essential features of suture closure as a result of our study of the White series before we commenced to investigate the Negroes.

The analytic graph of sagittal closure (Fig. 2) should next be studied. The obelica begins to unite at twenty-two years. This is a year later than in the Whites but as in them, once it has started it continues rapidly to its completion which is attained at thirty-one years, two years later than in the Whites.

The lambdica also commences to close at twenty-two, shortly before the lambdica in the Whites. It progresses slowly till twenty-five and then shoots up rapidly to completion at thirty-one.

The bregmatica shows closure activity first at twenty-three, continues very slowly until twenty-seven and then rises quickly to complete union at thirty-one.

The pars verticis commences at twenty-four and follows the same pattern thereafter as the bregmatica.

In all these subdivisions of the sagittal suture there is no essential difference from the closure graph characteristic of White males. We are compelled to admit that so far as endocranial sagittal closure is concerned Negroes and Whites conform to a single pattern.

2. THE CORONAL SUTURE (Figs. 1 and 3)

Comparison of the White and Negro curves shows strikingly little difference in period or in rate of closure. This is quite compatible with our findings for the sagittal suture. The slight differences in the body of the curves probably results from the sampling. Closure in the Negro occurs in the following manner:—

Male Negro endocranial coronal closure commences at twenty-four with

- (a) an initial gradual rise to about twenty-six, quickly changing into
- (b) a fairly steep rise to 3.6 at thirty-two, after which there is
- (c) a slackening in rate but continuous progress to
- (d) complete closure at thirty-five years.

Age	Period	Number of skulls	
		Retained	Rejected
17-23	pre-(a)	17	7
24-31	(a) + (b)	19	9
32-34	(c)	3	4
35-76	(d)	40	21

Percentage of discards (a)-(c) inclusive on total of these periods. 37.1

The analytic curves dissecting coronal closure into right and left sides and into bregmatic and complicated portions (Fig. 3) show the following features:—

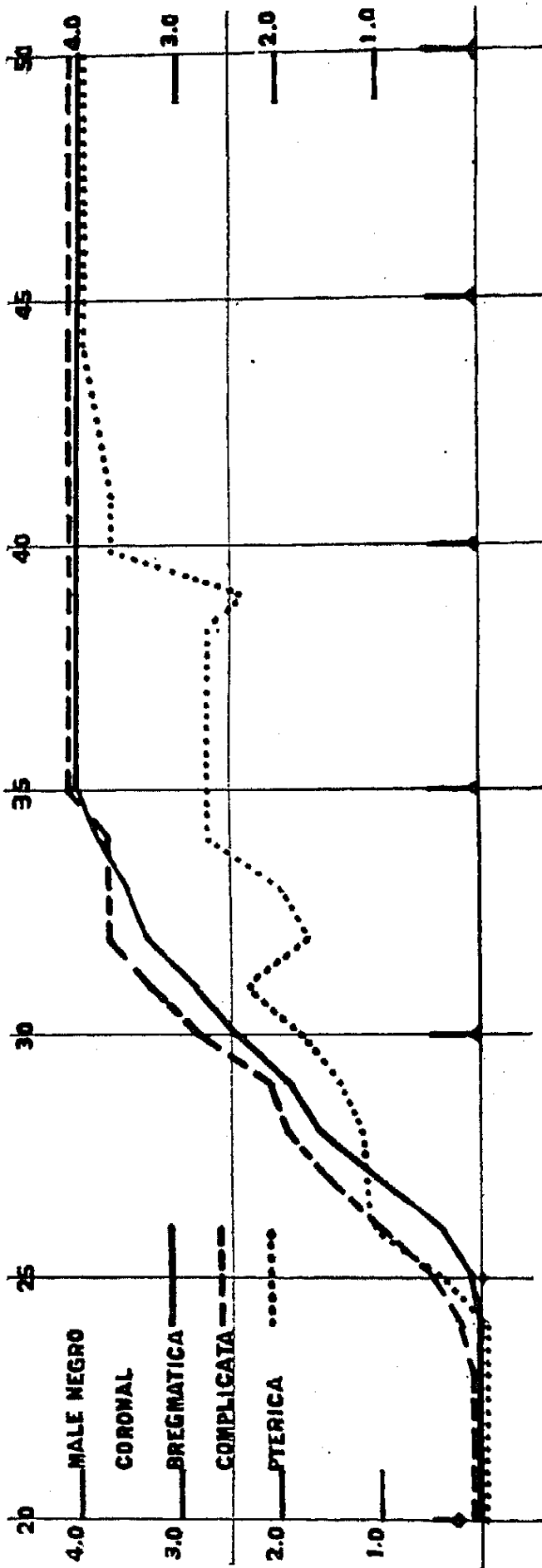


Fig. 3. Endocranial closure progress in the coronal suture. A marked distinction is present between the pterica and the other part of the suture.

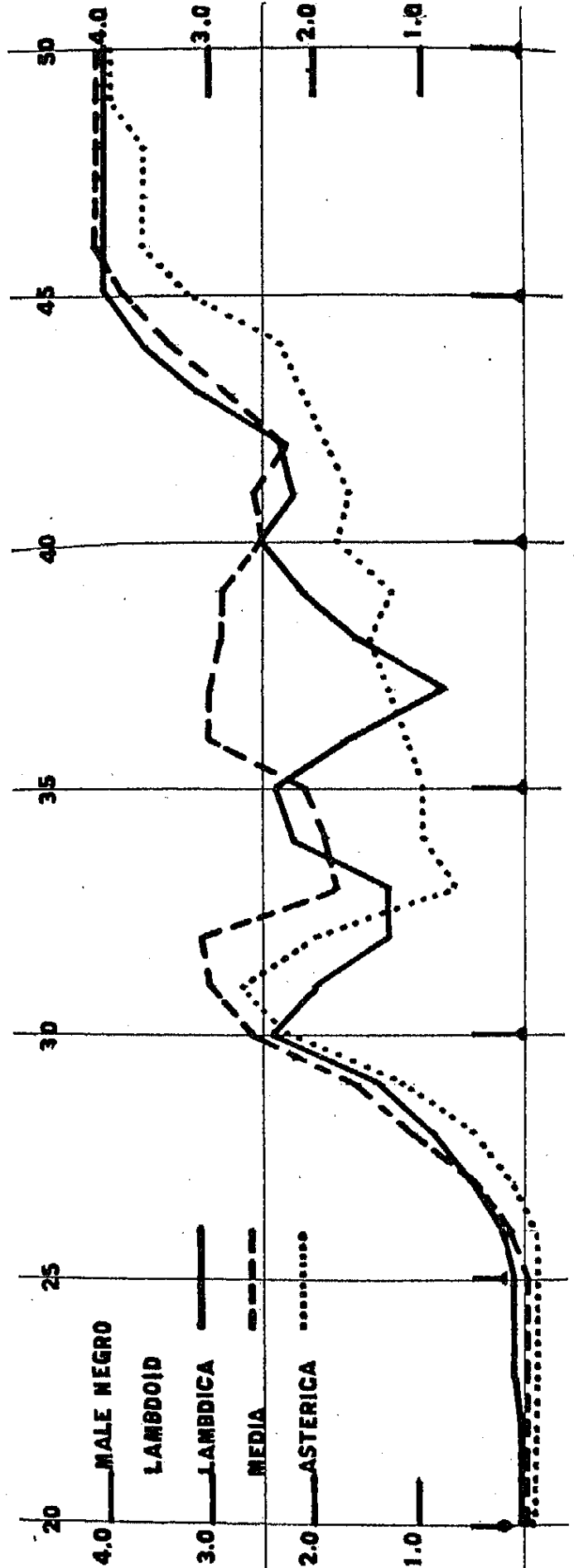


Fig. 4. Endocranial closure progress in the lambdoid suture. The great individual variability evident in this graph is characteristically

Pars	Side	Commences to close at	Complete Closure at
Bregmatica	Right	26	35
"	Left	25	34
Complicata	Right	24	35
"	Left	22	35

The question scarcely arises as to whether there is anything significant in these differences, for it is quite obvious that they are entirely the result of random sampling.

In comparison with the corresponding results for the male White there is again no real difference. It is true that there seems to be a slight delay in commencement of closure in the bregmatic part of the Negro but this is counterbalanced by the equally slightly earlier completion of union in the complicata of the same Stock.

CLOSURE OF THE PTERIC PART OF THE CORONAL SUTURE

As in the male Whites so in the Negroes we find it advisable to separate the pteric part of the suture from the rest since it exhibits quite a different age relationship in closure. Union first makes its appearance at twenty-five, shortly after it has begun in the other parts. It continues rather rapidly until thirty-one when the retarding influence slows down the process which however continues erratically until union is completed at forty-four.

The facts then are as follows:—

Male Negro endocranial coronal closure (pterice part) commences at twenty-five years and

- (a) continues steadily until it is checked at thirty-one after which
- (b) a slower and more erratic progress is made to
- (c) complete closure at forty-four years.

Age	Period	Number of skulls	
		Retained	Rejected
17-24	pre-(a)	22	7
25-30	(a)	13	9
31-43	(b)	19	19
44-76	(c)	25	6
Percentage of discards (a+b) on total of these periods.....			46.7

The same delaying influence observed in the male Whites at twenty-nine makes its presence felt in the Negroes at thirty-one. I do not regard this difference of two years as in any way significant; it is probably merely a result of the sampling. Nor can I consider the delay of one year in the commencement of union in the Whites as important. The fact that union is not complete in the Negroes until three years after it is attained in Whites again is shown to be devoid of real meaning by the appearance

of the graph which indicates that practical completion occurs at approximately the same age in both Stocks.

3. THE LAMBDOID SUTURE (Figs. 1 and 4.)

As in the White series we shall separate the asteric portion from the lambdoid and medial parts. Less than in either the coronal suture of both Stocks or in the lambdoid suture of the Whites is this segregation actually indicated. Were the Negro lambdoid suture to be treated alone such segregation would seem quite uncalled for. It is in this fact that the real importance of the treatment finds its justification. The delaying influence upon closure which we have observed so clearly marked in the coronal suture of both Stocks and in the lambdoid of Whites is very pronounced in the Negro lambdoid suture. In this suture the retarding influence is at work not only upon the asteric part but also in pronounced degree upon the remainder of the suture. So effective may it be that there is more or less deficiency of union throughout the suture. Indeed the majority of the discards among the Negroes result from delay in lambdoid closure from which the natural inference is made that the Negro tends more and more towards complete emancipation of the lambdoid suture from any closure. The Negro lambdoid appears to be in transition, as it were, from a true suture of the vault to one of the circum-meatal group. What may be the reason for this can at present be merely the subject of conjecture: it must be discussed later in the work. For the present we note that the markedly erratic nature of lambdoid closure is quite in harmony with our general theory of emancipation. Even a casual examination of the graphs will serve to impress the facts which have led us to this interpretation.

Closure commences at twenty-three

- (a) gradually gathering speed until thirty when
- (b) a period of stagnation sets in pricked out by oscillations which lasts to the age of forty-two
- (c) when once again progress begins and continues till
- (d) complete closure is attained at forty-six.

These facts may be delineated in the following manner:—

Age	Period	Number of skulls	
		Retained	Rejected
17-22	pre-(a)	11	6
23-29	(a)	22	9
30-41	(b)	21	20
42-45	(c)	3	3
46-76	(d)	19	6

Percentage of discards (a)—(c) inclusive on total of these periods. 41.0

Analysis of the figures shows that union commences on both sides of the pars lambdica at twenty-three years and is complete at forty-five.

In the right pars media it begins at twenty-three and reaches completion at forty-six whereas on the left side it begins at twenty-six and is completed at forty-five.

ENDOCRANIAL CLOSURE OF THE LAMBDOID SUTURE (PARS ASTERICA)

In the asteric part closure does not make its appearance in this series until the age of twenty-seven

- (a) from which it proceeds fairly rapidly until thirty-one
- (b) when stagnation supervenes and continues until forty-four.
- (c) At this age a new activity occurs in the progress of union lasting until forty-six,
- (d) by which date closure is practically complete at 3.8.

The last stage terminates more slowly in total union at forty-nine.

Age	Period	Number of skulls	
		Retained	Rejected
17-26	pre-(a)	26	12
27-30	(a)	9	4
31-43	(b)	19	19
44-45	(c)	3	3
46-48	(d)	6	1
49-76	(e)	13	5
Percentage of discards (a)-(d) inclusive on total of these periods.....			42.2

THE NEGRO DISCARDS

The discards of thirty years and under have already received full treatment in our discussion of the sagittal suture. The method by which we decided upon rejection has also been adequately presented in that chapter and in the paper on the White male endocranial sutures (2). Most of the discards of thirty and under have been rejected on account of precocious union. We have still to deal with another type of reject, namely that which has been discarded because of the delayed union more or less widespread among the sutures. These have been gathered together into a tabulated list and are presented below in formula in Table II (for explanation see 2, pp 331-2) so that a glance is sufficient to bring out the significant anomalies. Perhaps it was excess of zeal that eliminated No. 709, or rather, failed to restore this skull after it had been eliminated upon other counts. But with this exception there is no doubt of the anomalous condition of the crania in this list. No. 709 really remains eliminated for safety's sake.

TABLE II. RETARDED DISCARDS.

Age 27.	No. 379.	Sagittal 0000; Coronal	R. 000	R. 000
			L. 000	L. 000
	No. 802.	Sagittal 0000; Coronal	R. 000	R. 000
			L. 000	L. 000

TABLE II. RETARDED DISCARDS. (Cont.)

Age 28.	No. 474.	Sagittal 0000; Coronal	R. 000	; Lambdoid	R. 000
			L. 000		L. 000
Age 29.	No. 402.	Sagittal 0000; Coronal	R. 000	; Lambdoid	R. 000
			L. 000		L. 000
	No. 563.	Sagittal 0000; Coronal	R. 000	; Lambdoid	R. 000
			L. 000		L. 000
Age 30.	No. 598.	Sagittal 0000; Coronal	R. 000	; Lambdoid	R. 000
			L. 010		L. 000
Age 33.	No. 596.	Sagittal 0000; Coronal	R. 000	; Lambdoid	R. 000
			L. 000		L. 000
	No. 638.	Sagittal 4343; Coronal	R. 130	; Lambdoid	R. 000
			L. 220		L. 000
	No. 705.	Sagittal 2000; Coronal	R. 444	; Lambdoid	R. 000
			L. 444		L. 440
	No. 709.	Sagittal 4444; Coronal	R. 430	; Lambdoid	R. 000
			L. 430		L. 000
Age 35.	No. 74.	Sagittal 0130; Coronal	R. 344	; Lambdoid	R. 043
			L. 344		L. 043
	No. 451.	Sagittal 2444; Coronal	R. 342	; Lambdoid	R. 000
			L. 442		L. 110
	No. 594.	Sagittal 0444; Coronal	R. 110	; Lambdoid	R. 000
			L. 210		L. 000
	No. 761.	Sagittal 1344; Coronal	R. 000	; Lambdoid	R. 000
			L. 000		L. 000
Age 35.	No. 906.	Sagittal 0044; Coronal	R. 000	; Lambdoid	R. 000
			L. 000		L. 000
Age 37.	No. 775.	Sagittal 0000; Coronal	R. 100	; Lambdoid	R. 000
			L. 000		L. 000
	No. 812.	Sagittal 0000; Coronal	R. 000	; Lambdoid	R. 010
			L. 110		L. 000
Age 38.	No. 388.	Sagittal 0440; Coronal	R. 342	; Lambdoid	R. 030
			L. 000		L. 030
	No. 416.	Sagittal 4444; Coronal	R. 000	; Lambdoid	R. 000
			L. 342		L. 000
	No. 538.	Sagittal 0040; Coronal	R. 000	; Lambdoid	R. 000
			L. 000		L. 000
	No. 779.	Sagittal 0000; Coronal	R. 000	; Lambdoid	R. 000
			L. 000		L. 000

TABLE II. RECORDED DISCARDS. (*Cont.*)

			R. 343	R. 000
	No. 891.	Sagittal 3420; Coronal	; Lambdoid	
			L. 343	L. 000
			R. 342	R. 000
Age 40.	No. 515.	Sagittal 0100; Coronal	: Lambdoid	
			L. 343	L. 000
			R. 444	R. 100
	No. 736.	Sagittal 1444; Coronal	; Lambdoid	
			L. 444	L. 100
			R. 000	R. 000
Age 41.	No. 835.	Sagittal 0000; Coronal	; Lambdoid	
			L. 000	L. 000
			R. 444	R. 000
Age 45.	No. 426.	Sagittal 4440; Coronal	: Lambdoid	
			L. 444	L. 000
			R. 031	R. 000
	No. 540.	Sagittal 1344; Coronal	; Lambdoid	
			L. 030	L. 000
			R. 044	R. 000
	No. 777.	Sagittal 0000; Coronal	; Lambdoid	
			L. 343	L. 000
			R. 444	R. 000
Age 48.	No. 198.	Sagittal 4441; Coronal	; Lambdoid	
			L. 444	L. 000
			R. 000	R. 000
Age 50.	No. 697.	Sagittal 0000; Coronal	; Lambdoid	
			L. 000	L. 000
			R. 443	R. 000
Age 67.	No. 522.	Sagittal 0243; Coronal	; Lambdoid	
			L. 444	L. 000

THE CIRCUM-MEATAL SUTURES

1. THE MASTO-OCCIPITAL SUTURE (Fig. 5)

According to our custom the suture is subdivided into superior, middle and inferior parts. Of these the superior and middle pursue a common course and the inferior has a pattern of its own though not so distinctly different from that of the other parts as in the male Whites.

SUPERIOR AND MIDDLE PARTS

Closure in the moving average begins for both segments of what we must now regard as the upper section at the age of nineteen years but it is only between twenty-five and thirty that considerable progress is made. Indeed the rise of earlier years is probably a spurious effort (see Part II p. 27). A period of marked oscillation now sets in and is only doubtfully broken by an effort at more complete union about forty-six. After this age there is again marked oscillation but no real indication of any further closure. These facts can be briefly set forth in the following manner:—

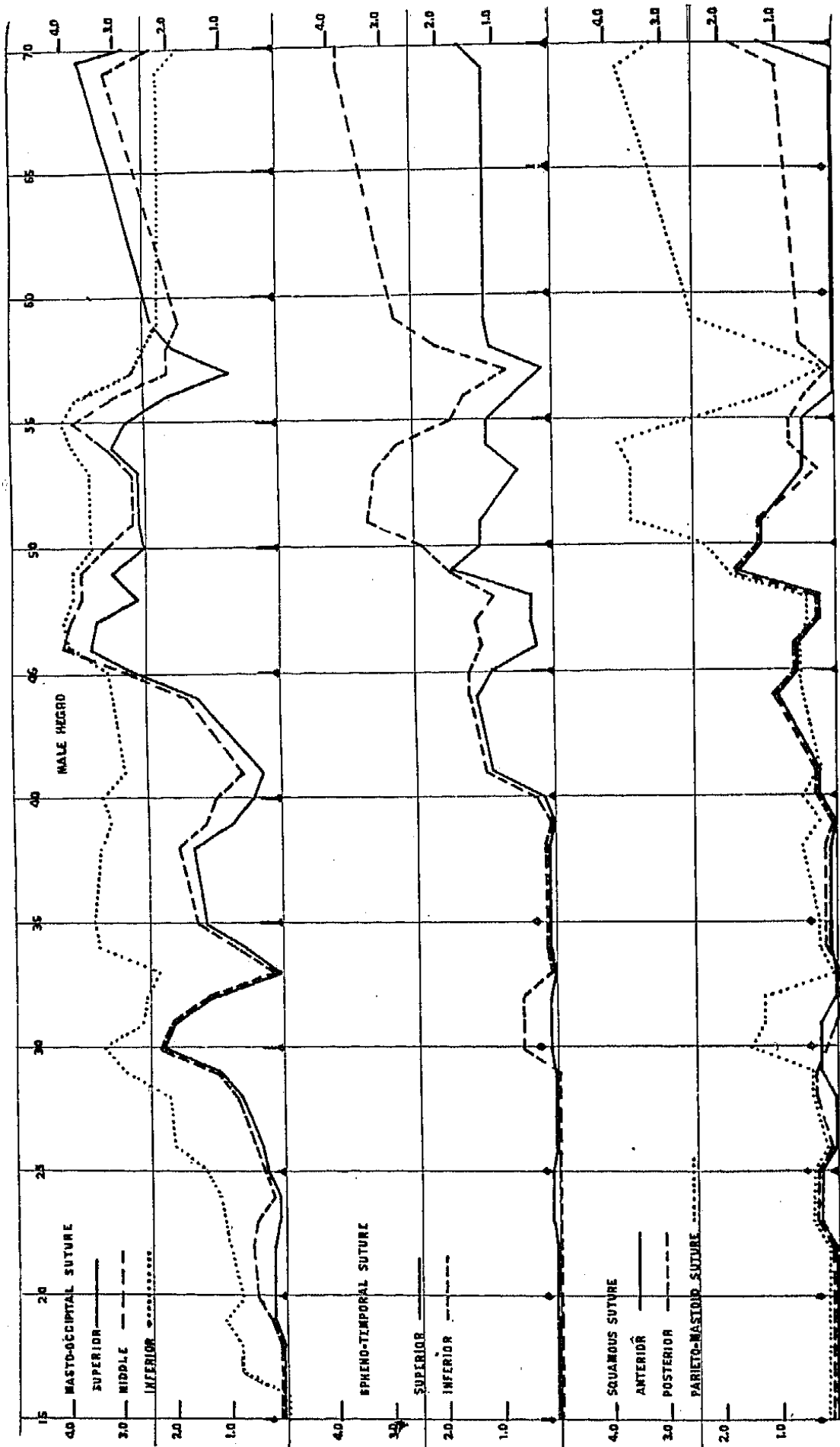


Fig. 5. Endocranial closure progress in the circum-meatal sutures. There is an erratic character in these curves which would be baffling were it not for the help of the White graph.

Age	Period	Number of skulls		
		Retained	Rejected	
17-24	pre-(a)	22	7	
25-30	(a)	13	9	
31-45	(b)	22	22	
45-76	(c)	22	3	
Percentage of discards (a)-(c) inclusive to total of this period.....				33.6

PARS INFERIOR

Closure in the inferior part is clearly defined by the moving average in the graph. It starts at seventeen years and continues fairly steadily to thirty when it reaches 3.3. Thereafter although there is a rise at forty-seven to 4.0 this must be regarded as one of the oscillations, for the graph demonstrates that there is no real progress after thirty years.

We may therefore arrange the facts thus:—

Age	Period	Number of skulls		
		Retained	Rejected	
17-29	(a)	33	15	
30-76	(b)	46	26	
Percentage of discards (a) to total of this period.....				31.2

2. THE SPHENO-TEMPORAL SUTURE (Fig. 5)

As with the male Whites we divide the speno-temporal suture into superior and inferior parts and treat these separately.

INFERIOR PART

Closure indeed makes its first appearance in the inferior part at thirty years but this is a spurious effort and there is little progress until forty when sudden activity occurs and carries the curve up to 1.2 within a year. From this time onward there is a gradual rise of the curve marked, it is true, by oscillations, until the maximum closure 3.9 is attained at sixty-nine. The really significant activity in this closure starts at forty, that during the previous decade being merely an abortive attempt due to incomplete emancipation in certain skulls. Attainment of the maximum occurs within two years of the date when the White male suture also reaches its maximum.

Age	Period	Number of skulls		
		Retained	Rejected	
17-29	pre-(a)	33	15	
30-39	(a)	14	17	
40-68	(b)	29	9	
69-76	(c)	3	0	
Percentage of discards to total of this period.....				23.7

SUPERIOR PART

Closure in the superior part of the suture appears erratically at first. There is a sporadic instance in one skull at twenty-four years which accounts for the obviously irregular rise of the curve at twenty-three.

Apart from this there is no other case until thirty and indeed the number showing any closure during the fourth decade is very small so that those can be considered spurious efforts. The curve does not again rise above 0.1 until forty when, like the curve for the inferior part, it swings upward suddenly within a year to 1.25. After this sudden rise the curve remains almost horizontal, barring oscillations, till old age.

Age	Period	Number of skulls	
		Retained	Rejected
17-29	pre-(a)	33	15
30-39	(a)	14	17
40-69	(b)	30	9
70-76	(c)	2	0

Percentage of discards (b) to total of this period. 23.1

The real difference between closure of the speno-temporal suture in Negroes and in Whites is the practical emancipation of the entire suture from closure in the former during the fourth decade.

3. THE SQUAMOUS SUTURE (Fig. 5)

Closure in the squamous suture of the Negroes is even more difficult to interpret than in the male Whites and the moving average is not of great assistance. A glance at the graph indicates at once the very marked irregularity of the curve. It is only in a minority of the cases that closure actually takes place at all. Sporadic union may occur as early as twenty-three years but there is no real progress until forty when the curve for the second part rises definitely and that for the first part rises until fifty-seven when it again returns to the base line. No attention should be paid to the terminal rise on this graph for it is none other than a sporadic rise like those of earlier years. The only useful inference which may be drawn from the graph for the squamous suture is that there is in the Negro much greater emancipation from closure than in the White but at the same time there are scattered instances, occurring even in early life, in which emancipation is seen only in small degree. The real significance of sporadic closure as early as twenty-three years is to be found in the general mammalian survey of suture closure to be set forth later on. Since however there is a genuine more general partial closure in the posterior part and this does bear to age some relation which can be correlated with closure in other sutures the main facts of the graph are set forward below:

Age	Period	Number of skulls	
		Retained	Rejected
17-22	pre-(a)	11	6
23-39	(a)	36	26
40-76	(b)	32	9

Percentage of discards (b) to total of this period. 22.0

4. THE PARIETO-MASTOID SUTURE (Fig. 5.)

As in the squamous the parieto-mastoid suture begins to exhibit union as early as twenty-three years but this is unusual and the curve only sporadically rises until thirty-three when the period of real closure begins. Progress is slow till forty-nine when the curve rapidly rises to a peak of 3.6 at fifty-one though closure is never quite complete. In the male White series closure begins at thirty-seven years. Consequently we should be inclined to disregard absolutely the Negro rise at forty-nine, were it not that the White graph seems to indicate renewed activity at fifty-one. Taking all facts into consideration it may well be that the real rise should commence about forty years and is masked on the graph by the random sampling. We may arrange the sequence as has been done in the case of other sutures.

Age	Period	Number of skulls	
		Retained	Rejected
17-32	pre-(a)	37	16
33-48	(a)	26	23
49-76	(b)	16	2
Percentage of discards (b) to total of this period..... 47.0			

THE ACCESSORY SUTURES

1. THE SPHENO-PARIETAL SUTURE (Fig. 6)

Closure of this suture in its course resembles very strongly the progress of union in the upper segments of the masto-occipital. Together with the features of speno-frontal closure this resemblance with the masto-occipital becomes almost as compelling as in the male White series. Both sutures exhibit retardation after thirty years and in each there is an effort of the curve to reach complete closure in the later forties.

The facts are then that

Closure commences at twenty-three with

- (a) a gradual rise to 2.7 at thirty after which
- (b) a period of stagnation marked by oscillations follows, ending with
- (c) a sudden rise to complete union at forty-nine.

Age	Period	Number of skulls	
		Retained	Rejected
17-22	pre-(a)	11	6
23-29	(a)	22	29
30-48	(b)	30	
49-76	(c)	16	2
Percentage of discards (a + b) to total of this period..... 38.8			

2. THE SPHENO-FRONTAL SUTURE (Fig. 6)

Again as in male Whites one cannot help noting the striking similarity in course of closure between this suture, of which the two parts pursue

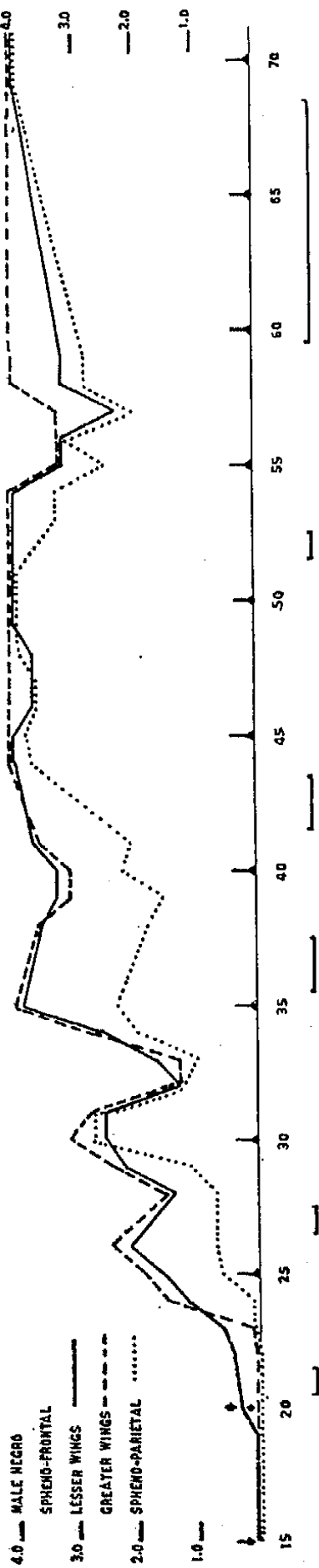


FIG. 6. Endocranial closure progress in the accessory sutures. The under-lines indicate sites where there were no skulls represented in the original series of seventy-nine. This defect no longer exists.

a strictly parallel course, and the inferior masto-occipital. Both commence at a rather unusually early age, show some slowing down about thirty years and both present an irregular course thereafter with some indication of a possible complete closure in the mid-forties.

Actually the facts for the speno-frontal are these. Union commences at twenty years and pursues a fairly steady course to 2.8 at thirty when the progress becomes markedly erratic. The complete closure which the graph shows at thirty-five must be understood to be simply a sporadic leap for nothing like steady maintenance of union takes place till forty-four and even then the curve does not retain absolutely its high position. Analysis of the graph shows that the suture in the lesser wings alone begins to unite at twenty, that for the greater wings following suit only at twenty-three, although once the latter has started, its progress parallels very closely the closure of the former. The dip on the graph occurring after fifty-four is a constant feature of this sample and undoubtedly should be considered an irregularity of the particular series.

We may then summarize in the following manner:—

- (a) Closure commences at twenty years for the lesser wings, followed at twenty-three by the greater wings and progresses steadily till thirty when there occurs
- (b) a slowing down of progress with a markedly erratic course until forty-four when
- (c) complete union is attained.

Age	Period	Number of skulls	
		Retained	Rejected
17-19	pre-(a)	5	2
20-29	(a)	28	13
30-43	(b)	21	20
44-76	(c)	25	6
Percentage of discards (a+b) to total of this period.....			40.2

COMPARISON OF WHITE AND NEGRO CLOSURE

For convenience we have submitted the essential features of Negro closure in the form of a table (Table III) and have reproduced the male White endocranial table (Table IV) for comparison. In the former we have adopted the same order as that used in the White series so that differences between the two tables will be the more striking. The first glance indicates that there is no very fundamental difference and we must therefore assume that Race, or as we should prefer to term it Stock, has no real relationship to pattern of endocranial closure. This conclusion is of course restricted by the evidence to White and Negro Stocks only. The large number of Negro rejects must however raise doubt as to whether our Negro graph is simply the result of our sub-

TABLE III. CRANIAL SUTURES—MALE NEGRO ENDOCRANIAL CLOSURE.

Suture	Commencement and course	Termination (or peak)	
Sagittal.....	22	31	slow to 26 complete
Spheno-frontal lesser w.....	20	44	complete
Spheno-frontal greater w.....	23	44	complete
Coronal 1 and 2.....	24	38	slows at 32 at 3.6
Coronal 3.....	25	44	slows at 31 at 2.3
Lambdoid 1 and 2.....	23	46	slows at 30 at 2.5 slow to 26
Lambdoid 3.....	27	46	slows at 31 at 2.7
Masto-occipital 3.....	17	30 at 3.3	no further progress
Spheno-parietal.....	23	49	slows at 30 at 2.7
Spheno-temporal 2.....	40	51 at 3.3	oscillations thereafter
Spheno-temporal 1.....	40	41 at 1.2	oscillations thereafter
Masto-occipital 1 and 2.....	25	46 at 3.5	no further progress
Parieto-mastoid.....	33	51 at 3.6	oscillations thereafter
Squamous posterior.....	40	49 at 1.7	oscillations thereafter
Squamous anterior.....	40	49 at 1.7	oscillations thereafter

TABLE IV. CRANIAL SUTURES—MALE WHITE ENDOCRANIAL CLOSURE.

Sagittal.....	22		35	slows at 31 at 3.9
Spheno-frontal lesser w.....	22	} slow to 26	64	slows at 30 at 3.0
Spheno-frontal greater w...	22		65	final burst of activity slows at 30 at 3.0
Coronal 1 and 2.....	24		38	final burst of activity slows at 29 at 3.4
Coronal 3.....	26	} rapid to ca 30	41	slows at 29 at 2.1
Lambdoid 1 and 2.....	26		42	slows at 31 at 3.4
Lambdoid 3.....	26		47	slows at 30 at 2.2
Masto-occipital 3.....	26		72	32-48 at 3.2
Spheno-parietal.....	29		65	slow progress thereafter 29-46 at 3.0
Spheno-temporal 2.....	30	} slow at once	67 at 3.9	gradual progress
Spheno-temporal 1.....	31		64 at 2.4	31-62 at 0.5
Masto-occipital 1 and 2.....	30		81	burst of activity at 63 32-45 at 1.25
Parieto-mastoid.....	37		81	activity between 46 and 64 final burst of activity almost inactive till 50
Squamous posterior.....	37	} almost inactive till 62	81	slow progress thereafter burst of activity at 63
Squamous anterior.....	37		81 at 3.2	burst of activity at 63 burst of activity at 79

conscious prejudice in favor of the White type. We have had this pitfall constantly in mind and are convinced that we have not fallen into it. The method of rejection has been exactly the same for both series and has not been based primarily upon suture closure at all except where gross anomalies were obvious.

Apart however from the method of rejection there are intrinsic characters of the series itself which indicate that we have correctly interpreted our facts. These have to do with the variability, with the direction of that variability and with the site of maximum variability. We have brought together, as Table V, the number of rejects in both series and

TABLE V. PERCENTAGES OF DISCARDS.

	White male	Negro male
Number in series	307	120
Total number of discards	40	41
Percentage	13.0	34.2
Number of precocious discards	4	10
Percentage	1.3	8.4
Number of retarded discards	36	31
Percentage	11.7	25.8

their percentages on the total number of the respective series. The total number of rejects in the Negro group is not far short of three times the number among the male Whites. In a general way these discards may be subdivided into precocious and retarded groups. It is true that we sometimes meet with a specimen displaying precocious closure in certain sutures and retarded union in others: we have grouped the crania according to the prevailing tendency. Retarded examples are nine times as frequent as precocious specimens in the White series: among the Negroes they are three times as numerous. Such variability as occurs in Whites tends more to retardation of closure than in Negroes but this does not mean a greater relative tendency towards retardation in Whites than in Negroes (see pp. 56, 62). It is apparent that, had we made an error in estimating the relative position of the modal type in Negroes, the Negro rejects should tail off in one direction further than the White discards. Now it so happens that the tailing off is in the direction of precocity and as we have already listed the discards one can readily examine the condition of the sutures of the precocious group. These are ten in number and include practically all the rejects from eighteen to twenty-seven years inclusive. We believe that a few minutes' study of Table I will convince the reader of the justice of our exclusion of these specimens. If they are discarded, the graph of the period of election for suture closure must necessarily take the form which we have given it. We have not thought it worth while to list the condition of the circum-meatal and accessory sutures in these specimens. In the former group there is no union at all in the speno-temporal suture; there is closure in part in the right squamous of No. 693, in the right parieto-mastoid of Nos. 693 and 695 and in both parieto-mastoids of No. 860. The entire masto-occipital is united on both sides of Nos. 695, 765, 860 and 190; the

right suture alone is united in No. 693 and the third part only on both sides of No. 716. Except No. 716 which is normal in its circum-meatal union all these are anomalous in circum-meatal closure as well as in the vault. The variability and direction of this variability in the Negro serve simply to confirm the modal type of closure which we have described.

The focus of variability in the Negro as in the White is the lambdoid suture. Other sutures are involved in some instances but it is the lambdoid which is most frequently and thoroughly implicated and this in spite of our elimination of lapsed union from the series of variables. This is quite in accord with the fact that in modal closure the coronal attains and holds a slight precedence over the lambdoid, a fact, be it noted, as characteristic of the Negro as of the White, contrary to established opinion. In human suture closure there is almost complete emancipation in certain of the circum-meatal sutures and with this emancipation there is a marked tendency to include the lambdoid. We cannot avoid the impression that the human cranium is expanding over the regions which include the squamous and lambdoid sutures in order to accommodate the enlarging brain. It must not be inferred from this that we imply any tendency in the human cranium to become more dolichocephalic. It is not possible to present here the evidence obtained in this laboratory on the problem of cranial development but we may state quite categorically that expansion in the lambdoid region does not involve any specific tendency towards either dolichocephaly or brachycephaly.

The greater irregularity of the graphs in spite of more careful and experienced combing, like the other evidences of variability already discussed, is characteristic of the Negro. We need not be at all surprised at this. Some time ago it was decided that some check observations must be carried out upon the apparently greater bodily variability in Negroes. For the check to be effective a part of the body other than the skull had to be chosen. Dr. T. A. Willis therefore undertook an investigation of the thoracico-lumbar spinal column. The results of this research have been already published (5) and fully bear out the theory of a greater variability in the Negro. In the vertebral column also these variations are about a mean common to White and Negro; they do not produce a specially skewed Negro curve.

Minor variabilities, not great enough to cause exclusion of the skull from our series, but still large enough to produce marked irregularity in the graphs, are also more frequent in the Negro series. In the vault sutures they are relatively infrequent in the sagittal but are apparent in

the coronal and lambdoid and are oftenest found in the circum-meatal and accessory sutures. So far as later progress in union is concerned there is no salient distinction between White and Negro series but in commencement the Negro speno-temporal lags behind the White by about a decade whereas the masto-occipital and speno-parietal precede by several years.

Comparison of the several Negro graphs reveals nothing specially characteristic or new in suture closure. The speno-parietal, the first and second parts of the masto-occipital and the third part of the lambdoid strongly resemble each other and so do the third part of the masto-occipital and the speno-frontal.

Much as existing prejudices and the statements of earlier writers have predisposed us to seek for some characteristic difference in Negro suture closure we have been quite unable to find any such condition.

According to Gratiolet (1) the sutures in White Stock ossify in a tardy manner compared with progress in Negro Stock. Comparison of tables III and IV shows indications of relatively accelerated progress in the Negro in the speno-frontal and speno-parietal sutures only and of retardation in the Negro in the entire circum-meatal group. It is possible that one should not emphasize this difference but certainly the occurrence of the difference indicates that there is no tendency on the part of the Negro sutures to earlier completion of ossification.

One notes with surprise bordering on amazement the extent to which prejudice and preconception have in the past called forth statements which scanty knowledge was unable to refute. In the article referred to Gratiolet continues:

“Has the long persistence of the patent sutures in the White race any relation to the almost indefinable perfection (*perfectibilité*) of their intelligence? Does not this continuance of an infantile condition seem to indicate that the brain may, in these perfect men, remain capable of slow growth? Perhaps it is this which makes the perpetual youthfulness of spirit in the greatest thinkers seem able to defy old age and death. But in idiots and in brutish races the cranium closes itself on the brain like a prison. It is no longer a temple divine, to use Malpighi's expression, but a sort of helmet capable of resisting heavy blows.”

LAPSED UNION IN NEGROES AND WHITES

The fact that we have been unable to find any significant difference between Whites and Negroes in date or progress of suture closure has caused us to doubt gravely the value of such earlier work as that of Gratiolet but before finally condemning previous writings on this point

we desire to present our evidence upon lapsed union for it is apparent that if this phenomenon occurs more frequently in White Stock it may have misled those with less opportunity than we have had for quantitative study.

The following table (VI) sums up our information regarding lapsed union. It is apparent from these figures that, considering the numbers

TABLE VI. LAPSED UNION—ENDOCRANIAL

	Male White	Male Negro
Total skulls.	307	120
Skulls showing lapsed union.	91	23
Percentage.	29.6	22.5
Number of cases		
Sagittal.	48	15
Percentage.	52.7	65.2
Bregmatica.	12	6
Verticis.	35	8
Obelica.	6	7
Lambdica.	21	6
Coronal.	5	4
Percentage.	5.5	17.4
Bregmatica.	4	3
Complicata.	0	1
Pterica.	1	0
Lambdoid.	67	12
Percentage.	73.6	52.2
Lambdica.	65	12
Media.	2	0
Asterica.	3	0

involved, there is no significant difference in the groupings. Such evidence as emerges from the table is quite contradictory to established views. Gratiolet speaks of the order of closure in White Stock as sagittal, lambdoid, coronal, and in Negro Stock as sagittal, coronal, lambdoid. Lapsed union could not have misled him, but indeed it is very doubtful if he had the opportunity to examine the interior of many crania. We must therefore conclude that the large number of Negro crania which show retardation in lambdoid closure, skulls which we are compelled to regard as abmodal (see p. 56), is probably the cause of this misleading statement by Gratiolet and others. Some change seems even now to be taking place in this region of the Negro cranium. We have expressed it earlier in this paper (p. 56) by suggesting that the Negro lambdoid suture appears to be taking on the characters of the circum-meatal group.

SUMMARY

1. Endocranial suture closure in the Negro presents no fundamental or essential difference in pattern of graph or in age relationship from closure in Whites.

2. Individual variability in minor details is much greater in the Negro.

3. Individual variability in major details, resulting in rejection of the cranium as anomalous in suture closure, is more frequent in the Negro but this variability is on both sides of the mean common to Negro and White Stocks.

4. There is a similar tendency towards lapsed union as in Whites.

5. As in the Whites the coronal suture attains and holds a slight precedence over the lambdoid in closure.

6. So far as our evidence goes there is one modal type of human suture closure unaffected by Race or Stock and human emancipation from the mammalian type of closure is focussed upon the squamous and its subsidiary sutures and upon the lambdoid.

7. There is nothing in our results to indicate any relation between cephalic index and the type, site, or degree of emancipation.

8. Many negro skulls have been rejected as abnormal because of delay in closure of the lambdoid suture. It appears that some change is even now taking place in this region of the Negro cranium.

REFERENCES

1. Gratiolet (P.)—1856. Mémoire sur le développement de la forme du crâne de l'homme, et sur quelques variations qu'on observe dans la marche de l'ossification de ses sutures. *C. R. Acad. Sci.*, XLIII, 428-431.
2. Todd (T. W.) and Lyon (D. W.)—1924. Endocranial suture closure, Part I. Adult males of White Stock. *Am. J. Phys. Anthrop.*, VII, 325-384.
3. Todd (T. W.) and Lyon (D. W.)—1925. Suture Closure, Part II. Ectocranial closure in adult males of White Stock. *Am. J. Phys. Anthrop.*, VIII, 23-45.
4. Todd (T. W.)—1923. Age changes in the pubic symphysis. VII. The anthropoid strain in human pubic symphyses of the third decade. *Journ. Anat.*, LVII, 274-294.
5. Willis (T. A.)—1923. The thoracico-lumbar column in White and Negro Stocks. *Anat. Rec.*, XXVI, 31-40.