

CRANIAL SUTURE CLOSURE

ITS PROGRESS AND AGE RELATIONSHIP

PART II.—ECTOCRANIAL CLOSURE IN ADULT MALES OF WHITE STOCK

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INTRODUCTION

In a recent paper we have announced our intention of making a complete study of cranial suture closure (6). We have already presented the results of our investigation of endocranial closure in White males and because of their relative constancy, we have proposed these results as a standard of comparison for our work upon ectocranial closure and Negro sutures. Our present task is to set forth as briefly as possible our findings on the subject of ectocranial closure in male White Stock.

It is only after discussing ectocranial closure that one can profitably compare our results with those of others for until now there has been little opportunity for systematic study of the inner surface of the cranium. Indeed in the work of most former writers one cannot be sure what statements refer to endocranial closure and what are the result of ectocranial study: many authors have simply contented themselves by saying that endocranial closure occurs somewhat earlier than and follows practically the same pattern as ectocranial closure.

Our investigation has disclosed the following broad facts.

1. There is no tendency on the part of the sutures to commence to close earlier on either aspect of the cranium. Inspection of our graphs

demonstrates that when closure begins it is equally evident both ectocranially and endocranially.

2. Ectocranial closure exhibits a slower and more variable progress and there is less evidence of periodic activity than endocranially.

3. Ectocranial closure on the whole is never so complete as endocranial union.

MATERIAL AND METHOD

It may be recalled that out of our large collection of skulls we chose for the study of endocranial suture closure 307 male White skulls, our two criteria being the existence of the entire skeleton and definite knowledge of the age. Of these 307 skulls 40 were rejected because of obvious anomalies in suture closure or for other sufficient reasons. The remaining 267 skulls form the basis alike of our investigations on endocranial closure and on ectocranial union, but for our study of ectocranial closure we have not hesitated to add more recent accessions to our collection since a greater number adds appreciable weight to the results.

There is no need to specify in detail the method of examination: that has been sufficiently described (6). It will be enough to state that the method is in all respects the same as that adopted for the endocranial sutures and once again the graphs are based upon a three-yearly moving average or trend. The trend is a specially sensitive indicator for the commencement of closure: this is noteworthy in the present work for the graphs show what we shall term a spurious commencement in the closure of many sutures. It is the result apparently of an effort of Nature, not well sustained, to start union first on the ectocranial surface.

Lapsed union has been described in our earlier paper. It presents certain well marked features which pick it out without difficulty wherever it occurs. Endocranially it is frequent in the lambdoid suture, especially in the pars lambdica where its occurrence has led previous observers into the erroneous view that closure is incomplete, and in the sagittal suture. Ectocranially it is characteristic of all sutures. It must not be confused with the lethargy in closure which develops at the termination of the period of election, namely shortly after thirty. The restraining influence responsible for lethargic closure is an inhibition but whatever brings about lapsed union is of the nature of a prohibition.

We shall not dwell upon the problem of the discards in this paper. No further discards have occurred and the method of rejection has already been fully described.

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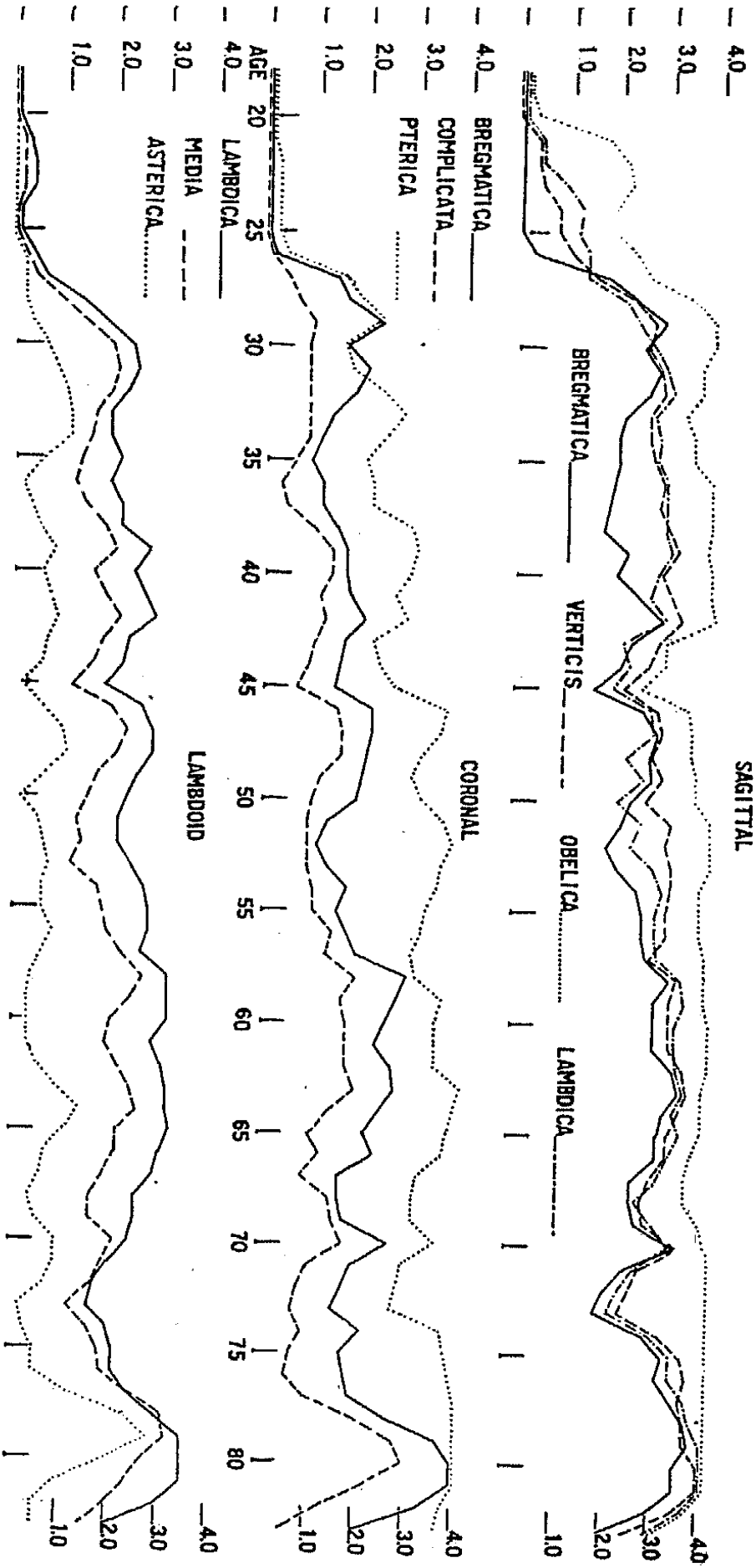


Fig. 1. Ectocranial closure progress in the sutures of the vault. The years between twenty-six and thirty form the period of election for suture closure. The pars obellica of the sagittal has a pattern of its own. Coronal progress slightly precedes lambdoid. The coronal pattern differs somewhat from the endocranial pattern (Fig. 4).

MALE WHITE ECTOCRANIAL

The terminal drop on all our ectocranial graphs is without significance. It results from a meager supply of aged crania and is allowed to remain in the graphs simply to emphasize the plain fact of individual variation.

No reference to right and left sides is made in this work: we find no essential difference in closure pattern and the discussion would have served only to prolong the paper without adding to its value.

Without further preamble we may consider the closure patterns of the several sutures.

I. SUTURES OF THE VAULT THE SAGITTAL SUTURE

Fig. 1.

In spite of the tendency for ectocranial and endocranial closure to commence and continue step by step together, within the limitations outlined above, there is no suture which better displays an attempt at discrepancy. This however affects merely the initial stages of closure. Comparison of ectocranial and endocranial graphs shows a single fundamental pattern for both.

The obelica is a law to itself: the partes verticis and lambdica run together and there is an initial lethargy in the bregmatica. This feature of the bregmatica is not apparent endocranially.

The main points in ectocranial closure are the following.

Closure in the pars obelica commences at twenty years with

- (a) a sharp rise to 2.1 at twenty-three,
- (b) a lethargic period until twenty-six,
- (c) a second period of marked activity terminating at twenty-nine years when closure has reached 3.9 which is of course practical completion.

Closure in the pars lambdica commences at twenty-one years with

- (a) a steady rise to 1.2 at twenty-four followed by
- (b) a pause until twenty-seven when there occurs
- (c) a sharp rise to 2.4 at twenty-nine years and
- (d) merely oscillations thereafter.

Closure in the pars verticis commences also at twenty-one years with

- (a) a gradual and probably retarded rise to 0.7 at twenty-five,
- (b) rapid progress to 2.7 at twenty-nine years and
- (c) merely oscillations thereafter.

Closure in the pars bregmatica commences at twenty-six and

- (a) rises rapidly to 2.9 at twenty-nine years with
- (b) merely oscillations on the graph thereafter.

There are certain features well exemplified by sagittal suture closure which should not be passed over. The partes verticis and lambdica,

though separated by the obelica, run a parallel course and the bregmatica, though catching up later, at first presents a pattern of its own. Hence we must not stress location too hard as an influence in determining closure pattern. The paramount influence is probably a much deeper one, of which location is merely one expression. The period of activity between twenty-six and thirty years is strikingly demonstrated and even more arresting is the evident lethargy or inhibition taking place about the latter age. Endocranially we have seen some evidence of secondary periods of activity succeeding this one and there is slight evidence ectocranially also but it is veiled by the failure of union to progress to completion.

The feature which, above all, one would like to emphasize is the plainly marked effort at closure which makes itself evident in the early twenties. If a suture shows no attempt at closure by twenty-two years it will not start until the period of special sutural activity, namely twenty-six years. This is very important: we shall term the phenomenon spurious effort and shall find it in suture after suture. Stevenson has shown the periodicity in epiphysial union (5) and we know that in the early twenties this activity undergoes a marked decline. Our belief is that certain sutures, being ripe as it were, get caught in the last phase of this activity and make their spurious effort. Further progress in their union is lacking for sutural union, like epiphysial union, becomes lethargic. When the real period of activity in sutural closure commences at twenty-six this dormant energy again is let loose and real progressive union takes place.

Endocranially closure in the sagittal suture commences at twenty-two years but a year earlier in the obelica, and by twenty-four has spread to all parts of the suture. In the obelica union progresses rapidly until its completion at twenty-nine but in the other three parts the progress is slow until the end of the twenty-sixth year when a spurt takes place and brings about practical completion of closure by thirty-one. We may safely disregard the final lethargy. The initial and terminal differences between ectocranial and endocranial union are of no particular significance. On both aspects there is the spurious effort in the early twenties quickly inhibited, and the characteristic rapid progress between twenty-six and thirty years.

THE CORONAL SUTURE

(Fig. 1.)

Ectocranially there is a pronounced difference between successive parts of the coronal suture and a tradition has grown up that so great

a difference in appearance is accompanied by a real difference in date of union. The actual facts about this suture show no such difference.

Closure in the pars bregmatica commences at twenty-six years with

- (a) a sharp rise to 2.3 at twenty nine and
- (b) no further progress but merely oscillations thereafter.

Closure in the pars complicata also begins at twenty-six with

- (a) a well sustained but not sharp rise to 0.9 at twenty-nine and
- (b) no further progress but merely oscillations in the curve thereafter.

Closure in the pars pterica commences at twenty-two years but

- (a) the initial rise which has reached only 0.4 by twenty-six is obviously of a spurious nature, whereas
- (b) real union then sets in with a sharp rise to 2.3 at twenty-nine and
- (c) continues as an oscillatory rise to 3.8 at about fifty years with
- (d) no further real progress.

There is some justification endocranially for the segregation of the pars pterica from the rest of the suture although it is true that the difference is not great, but it is of the order and in the direction which one would expect. Ectocranially one does not find this difference: the early spurious rise need not be taken into account. The influence, whatever it may be, which totally prohibits completion of ectocranial union—resulting in lapsed union as we have termed the phenomenon—is more pronounced in the upper and middle parts of the suture. Whereas endocranially complete union of the pterica has taken place by forty-one years this is delayed ectocranially until fifty. Apart from this fact there is no real difference in closure on the two cranial aspects in any part of the suture.

THE LAMBDOID SUTURE

(Fig. 1.)

On the endocranial aspect we found it advisable to separate the pars asterica from the remainder of the suture. Ectocranially also there is a distinction and by its nature this distinction serves to accentuate the difference already defined. We may nevertheless set down the main features of lambdoid closure together.

Closure in the pars lambdica commences at twenty-one years with

- (a) a spurious rise which rapidly fades from the graph and is replaced by
- (b) the real commencement at twenty-six which rises to 2.3 at thirty and

(c) is followed merely by oscillations.

Closure in the pars media also commences at twenty-one with

(a) a spurious rise which rapidly fades and gives place to

(c) the real commencement at twenty-six which rises to 1.9 at thirty

(c) and is followed by oscillations only.

Closure in the pars asterica commences at twenty-six with

(a) a slow rise to 0.6 at thirty

(b) seeming to be continued to 1.2 at thirty-four but in reality this is nothing more than a swing of the characteristic oscillations.

Lambdoid closure ectocranially occurs then simply between the ages of twenty-six and thirty. The graph shows selective action of the inhibitory influence very well: it is most pronounced in the asterica and least in the lambdica. Ectocranial and endocranial union keep pace with each other in very accurate fashion, allowing for the lapsed union of the ectocranial surface, for in all parts of the suture closure commences at twenty-six and the rapid progress ends at thirty. Further, inhibition seems to have the same relative effect upon the three parts on both aspects.

II. THE CIRCUM-MENTAL SUTURES

In this group of sutures the only one to show any closure activity in the typical period of twenty-six to thirty years is the masto-occipital and it is very slight. The inferior part, which attains considerable union endocranially before thirty, progresses very little on the outer surface by this age. The spurious start of the parieto-mastoid suture is probably the result of an accidental overflow of the abundant closure energy of the period.

In general, inspection of the graphs shows nothing but a slow, continuous but oscillatory progress. But closer study seems to disclose periods of secondary activity commencing about thirty-seven and sixty years. We happen to know from other researches that there is a significant activity commencing in the skeleton about thirty-seven which results in the formation of rims to the articular surfaces, a feature hitherto confused with pathological lipping. There appears to be no good reason why suture closure may not share in this energy. The cause of the activity about sixty has not yet disclosed itself to us.

The ectocranial features of closure in this group very closely resemble those of endocranial union but owing to a greater effect of the restraining influence all delicate distinctions between the several parts of the

various sutures is lost. Endocranially we were able to demonstrate varying degrees of emancipation from the typical pattern as exemplified by the vault sutures. This emancipation reaches its apogee in the squamous suture and becomes less as one follows the sphenotemporal forward or the parieto-mastoid and masto-occipital backward. Ectocranially however squamous, parieto-mastoid and sphenotemporal all commence to unite about thirty-six to thirty-eight and the masto-occipital between twenty-six and twenty-eight. Having in mind the scheme of emancipation so clearly shown on the endocranial aspect it is not difficult to pick out a similar but much less marked closure pattern on the external aspect.

THE MASTO-OCCIPITAL SUTURE

(Fig. 2.)

On the endocranial aspect the third or inferior part of the masto-occipital suture shows quite clearly a pronounced activity in closure during the typical period of suture closure, that is, between twenty-six and thirty years. Ectocranially this marked rise of the curve is not apparent and consequently there is nothing in this graph to arrest attention: all parts of the suture seem to be closing gradually and with more or less regular progress. No justification exists for separating the inferior part from the other two parts in description. No better instance could be cited of the relatively featureless pattern of closure on the ectocranial aspect when compared with endocranial closure. Had we depended upon ectocranial closure for our fundamental investigation, as so many of our predecessors have been compelled to do, we should have found it difficult if not impossible to unravel the tangled skein of suture closure.

The facts concerning union in the masto-occipital suture are the following.

Closure in the pars superior shows

- (a) a spurious commencement at twenty-one years quickly fading and
- (b) giving place to the real start at twenty-eight which rises to a peak of 0.8 at thirty-two years and continues as
- (c) an oscillatory but certain slow progress attaining a final peak of 3.0 in old age.

Closure in the pars media is essentially the same: there is

- (a) a spurious rise at twenty-two followed by
- (b) the real commencement at twenty-eight which rises to a peak of 1.0 at thirty-two and gives place thereafter to

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MALE WHITE ECTOCRANIAL

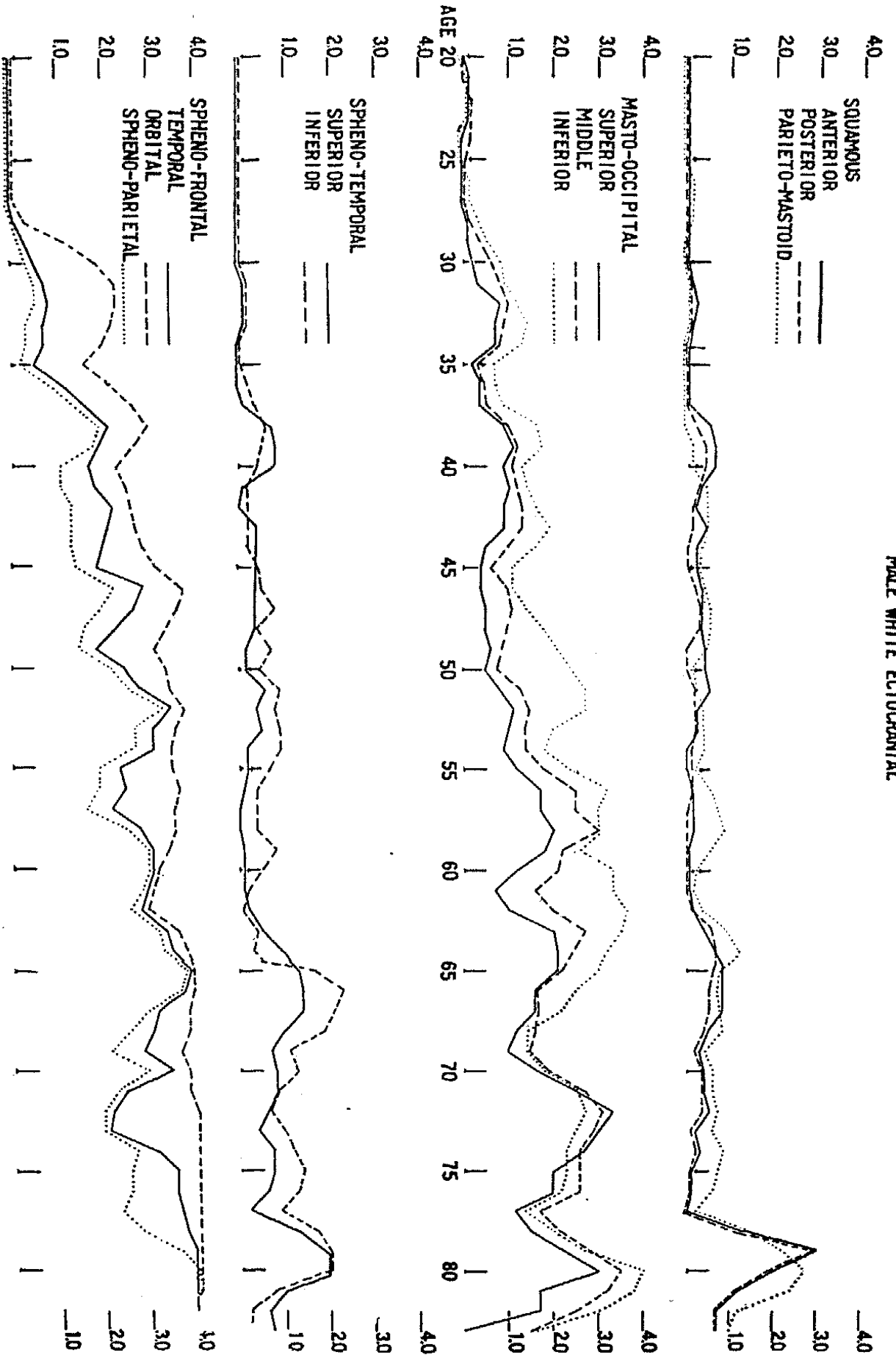


Fig. 2. Ectocranial closure progress in the circum-mental and accessory sutures. Progress in all these except the spheeno-frontal is obviously different from that of the vault sutures. The patterns of the inferior masto-occipital and of the spheeno-frontal differ from the corresponding endocranial patterns (Figs. 6, 7). Evidence of subsidiary periods of activity appear in these sutures in the late thirties and about sixty. The final drop is the result of very few aged skulls erratic in their suture closure. Lapsed union is characteristic of all ectocranial sutures.

(c) an oscillatory but nevertheless progressive union reaching a peak of 3.5 in old age.

Closure in the pars inferior presents

- (a) the usual spurious rise: it commences at twenty-one years but
- (b) the real start is seen at twenty-six and by a rapid rise the curve climbs to 1.4 at thirty-three after which there is
- (c) oscillatory progress until a peak of 3.6 is reached at sixty-two with the possibility of complete closure in extreme old age.

Both ectocranially and endocranially the pars inferior commences to unite at twenty six and there is more marked progress endocranially, less marked progress ectocranially, until thirty but the impetus is carried over on both aspects until thirty-three years when an oscillatory appearance of the graph obscures the changes which the suture is undergoing. Endocranially there seems to be some evidence of a rather stationary period terminating in a fresh subsidiary activity at about forty-nine years which continues throughout life thereafter. Ectocranially one cannot distinguish this periodicity.

In the superior and middle parts of the suture closure commences ectocranially at twenty-eight but endocranially not until thirty years. There follows a short period of considerable activity terminating on both cranial aspects at thirty-two, the endocranial aspect showing by then a greater degree of union than the ectocranial. If the periodicity suggested on the endocranial aspect be genuine it is very feeble and does not appear at all on the outer surface of the cranium. There is however on both sides a slow progress maintained throughout the greater part of life.

THE SPHENO-TEMPORAL SUTURE

(Fig. 2.)

Ectocranially there is no advantage in separating the descriptions of the two parts.

Closure in the pars superior shows

- (a) a slight and probably spurious commencement at thirty-one years,
- (b) the real commencement at thirty-seven with little or no progress
- (c) but a secondary spurt in the early sixties with
- (d) merely oscillations thereafter.

Closure in the pars inferior also shows

- (a) a probably spurious effort at thirty-one years,
- (b) the real start at thirty-six, again with little progress but

- (c) a secondary period of activity about sixty-five and
- (d) oscillations thereafter.

Endocranially there is the same early activity at thirty years which rapidly comes to an end and is probably spurious, the real commencement appearing in both parts at thirty-six. There is little further activity in the pars superior until the spurt occurs in the early sixties but the pars inferior shows no such spurt. In it there is continuous slow progress as on the outer aspect of the cranium, reaching its maximum in the later sixties.

THE SQUAMOUS SUTURE

(Fig. 2.)

On the ectocranial aspect of the cranium as on the endocranial it is unnecessary to separate the anterior from the posterior part of this suture in treatment. The closure curves for both parts and indeed for both aspects run almost parallel. Ectocranially there is an obvious false start in both parts at thirty-one years. These spurious efforts may be disregarded: they are characteristic of all circum-meatal sutures.

Closure in both parts

- (a) apart from the spurious effort starting at thirty-one years,
- (b) commences at thirty-eight and reaches its peak in one year, namely 0.6 for the anterior part and 0.5 for the posterior. Then follows
- (c) a period of oscillation with perhaps
- (d) a spurt of secondary activity in the early sixties.

Closure in this suture commences on both sides of the cranium at thirty-seven or thirty-eight and the secondary activity in the early sixties is well marked endocranially. As usual, closure progresses to a much greater degree on the endocranial aspect than on the ectocranial.

THE PARIETO-MASTOID SUTURE

(Fig. 2.)

As on the endocranial surface, closure of the parieto-mastoid suture closely follows union of the squamous. There are two spurious efforts at twenty-six and thirty-one years before the real start. Whether there is simply oscillatory progress or an actual secondary period of activity in the late fifties and early sixties one finds it difficult to decide: the probability is in favor of secondary activity.

Closure starts

- (a) after two spurious efforts
- (b) at thirty-nine and makes very little progress until there appears

- (c) a secondary period of activity in the late fifties and early sixties when a peak of 1.2 is reached at sixty-four and thereafter
- (d) merely oscillations.

Endocranially closure starts at thirty-seven and shows the same lethargy until the secondary activity of the fifties.

III. THE ACCESSORY SUTURES

The two parts of the speno-frontal suture are not strictly comparable on the two aspects of the cranium and one finds quite a different scheme in the graphs. Endocranially the two parts run a parallel course different from that of the speno-parietal, but ectocranially the orbital part runs its own course whereas the temporal part and the speno parietal suture run practically the same course.

One can trace relationship with vault suture pattern in the orbital part alone. The speno-parietal and the temporal speno-frontal on the other hand resemble in their graphs the inferior speno-temporal and in a general way the masto-occipital also in all its parts. One would be very unwise however to inspect these ectocranial graphs alone in the hope of obtaining a mental picture of the suture closure relationships. An indispensable preliminary is the study of our endocranial graphs.

THE SPHENO-PARIETAL SUTURE

(Fig. 2.)

The ectocranial graph for the speno-parietal suture is an almost exact replica of the endocranial graph but with somewhat less progress year by year.

Closure commences at twenty-eight years

- (a) with a slight rise to 0.5 at thirty-one sustained until the
- (b) secondary period of activity commencing at thirty-six and reaching 2.0 at thirty-eight but
- (c) continuing with diminished and oscillatory vigor until the early sixties.

Endocranially closure begins at twenty-nine and also encounters the delaying influence almost at once. The same spurt in the late thirties is apparent and the continued oscillatory activity. At sixty-five complete closure is attained.

THE SPHENO-FRONTAL SUTURE

(Fig. 2.)

The similarity of the graphs of the two parts, so characteristic of the endocranial surface is not to be found on the ectocranial aspect: nor is there an early start ectocranially.

Closure in the temporal part commences at twenty-eight with

- (a) a gradual rise to 0.7 at thirty-one sustained until thirty-five;
- (b) then a fairly sharp rise to 2.1 at thirty-eight followed by
- (c) a slow oscillatory progress until sixty-five when complete closure may be attained.

Closure in the orbital part commences also at twenty-eight with

- (a) a rapid rise to 2.3 at thirty-one sustained until
- (b) secondary activity sets in at thirty-six and continues until forty-six when the graph reaches 3.8. This activity is followed by
- (c) merely oscillations thereafter.

On the endocranial surface closure in both parts starts at twenty-two, rises to 0.7 at twenty-six and 3.0 by thirty years. After this there is a period of oscillation lasting until sixty-four when complete closure takes place.

The orbital part of the speno-frontal suture is the only one of the accessory group which at all resembles the pattern of the vault sutures. Its graph recalls those of the lambdica and media of the lambdoid. Endocranially the inferior part of the masto-occipital looks quite like it but there is no resemblance ectocranially. On the other hand the asterica of the lambdoid quite closely resembles in pattern the graphs of the temporal part of the speno-frontal and of the speno-parietal. One would easily lose one's way in the maze of ectocranial patterns were it not for the help afforded by the endocranial graphs.

COMPARISON OF STANDARDS

Our work differs fundamentally from that of almost all previous investigators because we seek to establish a definite age relationship in the closure of sutures whereas they, dealing with a number of crania of unknown and quite various age, could base their observations solely upon a general average which they termed a closure tendency. It is apparent that this closure tendency would differ with every collection of crania. Previous workers have been compelled also by circumstances to concentrate the bulk if not the whole of their investigations on the exterior of the cranium: few have had the opportunity of studying any of the endocranial sutures save those of the vault. This being the case it would simply be wearisome and indeed profitless to make comparison with previous results in detail: by their nature they could have merely a temporary value and may now be considered obsolete.

Regarding certain of the major conclusions we should however say a few words. It has been asserted that ectocranial closure is a very

different thing from endocranial union, that it commences in a different part of the suture, progresses in a different order and at a different speed. We have shown that, apart from the inferior masto-occipital, the spheno-frontal and in certain respects the coronal, the pattern of the closure graph differs in no essential on the two cranial surfaces. Why these differences should be present in the sutures mentioned we are not yet in a position to explain. As regards precise site of commencement in the several parts of any suture we consider too detailed an insistence as merely a meticulous pedantry: closure commences in the substance of the bone and naturally appears on the surface at rather irregular points and this detail is without significance. We have also shown that lapsed union, so characteristic endocranially in the pars lambdica of the lambdoid suture but by no means uncommon in the sagittal suture, is also characteristic of all the ectocranial sutures and to a much greater degree. Why this should be so we are not yet able to explain. There is no doubt, as our graphs demonstrate, that this lapsed union is the feature which has misled previous workers and brought about the belief that suture closure tends to occur earlier on the endocranial aspect. It is indeed somewhat surprising that the spurious efforts at closure so obvious in our ectocranial graphs, resulting from a precocious attempt at union in certain crania, has not drawn previous workers into the erroneous assertion that closure tends to take place earlier on the exterior of the cranium. The relative order of closure and the date at which each suture commences to unite, as given by former investigators, we would simply turn out of court as unsatisfactory and frequently prejudiced evidence. If the reader will take the trouble to read again at this juncture the historical introduction to our first paper (6 pp. 326-330) he will appreciate better the value to be placed on each of the main investigations previously published upon the subject. We are content to rest our case and will occupy no more space with a discussion which we regard as unnecessary.

THE SKULL OF DESCARTES

In our former paper we have drawn attention to the difference between the significance of this work for modal closure order and dates of a population on the one hand, and for the determination of age in individuals on the other. We have claimed, and we persist in our claim, that while there are individual differences of frequent occurrence in order and date, sometimes even of considerable magnitude, our final published graphs do give the modal order and dates for the population at large. We have already shown by a special investigation how far our

conclusions may be depended upon for discussion of an individual skull (6 pp. 379-380). Instead then of continuing this theme in the present paper we propose to discuss a single well known skull, namely that claimed to have belonged to the famous philosopher Descartes.

The authenticity of this cranium has been repeatedly called in question, first by Lenoir in his letter to Cuvier, most recently by the Académie des Sciences in 1912. Verneau (9) gives a brief history of the wanderings of the skull up to the time when it was sent by Berzélius to Cuvier in 1821 by the hand of the Swedish ambassador in Paris. Both Verneau and Richer (4) conclude that the skull is authentic by comparison with the portrait by Franz Hals. This indeed was the basis upon which Cuvier inclined to accept the skull as genuine. It is true that comparison with other portraits has not such a happy result but Miss Tyldesley has shown in her excellent study of the skull and portraits of Sir Thomas Browne that portraits have often been copies one of another and that the artistic convention of the day has brought about alterations in proportions so great that the original resemblance may be and often is entirely lost (8). So far as this method of study permits comparison there seems no good reason to doubt that the skull is indeed that of Descartes.

Ribbe in 1885 (4) took pains to examine the skull carefully and notes that although Descartes was fifty-four years old at the date of his death union of sutures had not yet begun. Presumably this refers to the exterior of the cranium. Comparing the cranium with those of other distinguished men in the Gall collection Ribbe concludes that intellectual men as a rule possess sutures which unite comparatively late in life. I am not in a position to discuss this point but, upon the basis of the results of our study of male white suture closure on both surfaces of the cranium, it is clear that the balance of evidence seems at first to be against the cranium being that of a man of over fifty years. Nevertheless the matter is worthy of further study. The texture of the cranium would yield very valuable information, for the bone in a skull of fifty years differs quite markedly from that of a skull of the third decade to which it ought normally to belong when the sutures show no sign of closure.

I have therefore reviewed our collection to see if I could match the condition found in the presumed cranium of Descartes and I find an apt comparison in No. 758, a White male, native of Austria, who died from a fractured skull at the age of fifty years. This cranium is mentioned in our earlier article (6 p. 360). It shows no endocranial union except in the pars complicata of the right coronal suture. Ectocranially

there is no union whatever. The capacity of this cranium is 1555 cc and it belongs to the δ group: that indicates a well filled cranium of a high type as will be shown in a forth-coming paper. The subject has already been discussed in a preliminary manner (7, pp. 250-252). The cranium is characteristically thin but it shows a peculiar texture associated in my experience with liability to fracture. I do not believe that size, texture or thinness is related to the lethargy in suture union: we have indeed the skull of an old Negress of seventy years (No. 152) in which also there is scarcely any trace of suture closure.

The author who, up to the present, has had the greatest experience of suture closure in skulls of known age is de Aranzadi who had at his disposal 1212 skulls, mostly of known individuals (1). This writer realized the magnitude of individual variability in date of suture closure and was forced to the conclusion that the cranium offers no certain sign (in suture closure of course) of the precise age of the individual to which it belonged. With this conclusion we quite agree although we insist that individual variability must not be allowed to obscure the fact that there is a modal progress which holds for the population in general.

So far as Descartes is concerned we would not seek to maintain that the unclosed condition of the sutures constitutes an insuperable bar to the presumption of authenticity for the cranium ascribed to this distinguished man, but we do not believe that his intellectual condition was necessarily associated with the lethargy of union, and we would emphasize strongly that the texture of the bone might well give surer evidence of the decade in which his death occurred.

Having mentioned Sir Thomas Browne we cannot but record our regret that sutures of this thoroughly authenticated cranium do not seem to have received adequate study before re-inhumation. Examination of the published figures yields only presumptive evidence that the sutures on the exterior also exhibit lack of union in spite of the fact that Sir Thomas was seventy-seven years old at the time of his death. This is in marked contrast to the suture condition of Immanuel Kant (2, pp. 373-375). If our interpretation of the cranium of Browne be correct we have one more example of the extent of individual variability. The published photographs show the texture of Browne's cranium to be that of a very old man.

SUMMARY

This paper is a continuation of the work upon suture closure and deals with ectocranial union in White males. We have presented evidence which we believe justifies the following conclusions.

1. Suture closure in general makes itself evident upon both ectocranial and endocranial aspects of the skull at one and the same date. The belief that endocranial closure precedes ectocranial union is without real foundation. To this there are exceptions where union may appear on one aspect a year or two before it is obvious on the other. Such differences are without significance. The pterica of the coronal suture is a case in point.

2. Ectocranial closure progresses more slowly and shows more individual variation than endocranial closure. It is therefore not so reliable as an age indicator.

3. Lapsed union so characteristic of parts of the lambdoid and sagittal endocranial sutures is equally characteristic of all ectocranial sutures. In consequence ectocranial sutures tend to remain in a state of incomplete union, some in very high degree.

4. The years twenty-six to thirty form the period of election for both ectocranial closure and endocranial closure. During this time most of the union which is going to occur takes place. There are however secondary periods of ectocranial activity, namely during the later thirties and about sixty years. These compare well with the evidence of the endocranial sutures. Ectocranially the third subsidiary period in extreme old age, namely in the late seventies, does not appear.

5. The closure patterns on the ectocranial surface are practically the same as those of the endocranial aspect except in the coronal, spheno-frontal and inferior part of the masto-occipital sutures. Why differences should occur in these sutures we are not yet able to explain.

6. Although closure occurs in coronal and lambdoid mainly during the period of election, namely between twenty-six and thirty years, ectocranially as well as endocranially, the coronal has a slight lead in the progress of closure.

7. Precise dates for suture closure and the order of progress are to be found in the text. It is unnecessary to repeat them here but there is no essential change from the endocranial patterns except in the sutures mentioned in paragraph 5.

8. The three types of suture, namely vault, circum-meatal and accessory, are apparent ectocranially but their segregation would not be very clear were it not fully demonstrated on the endocranial aspect.

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CRANIAL SUTURE CLOSURE

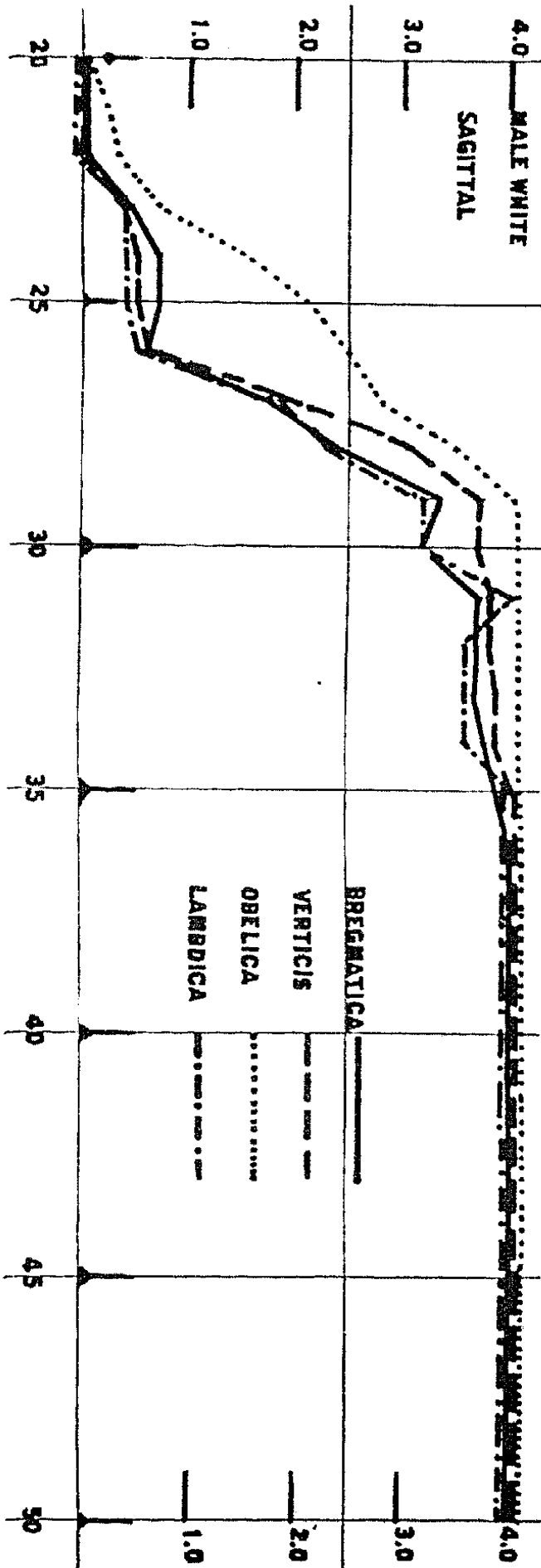


Fig. 3. This and the succeeding four figures of endocranial closure are inserted for comparison. Closure pattern on the endocranial aspect of the sagittal suture. Note the obellica.

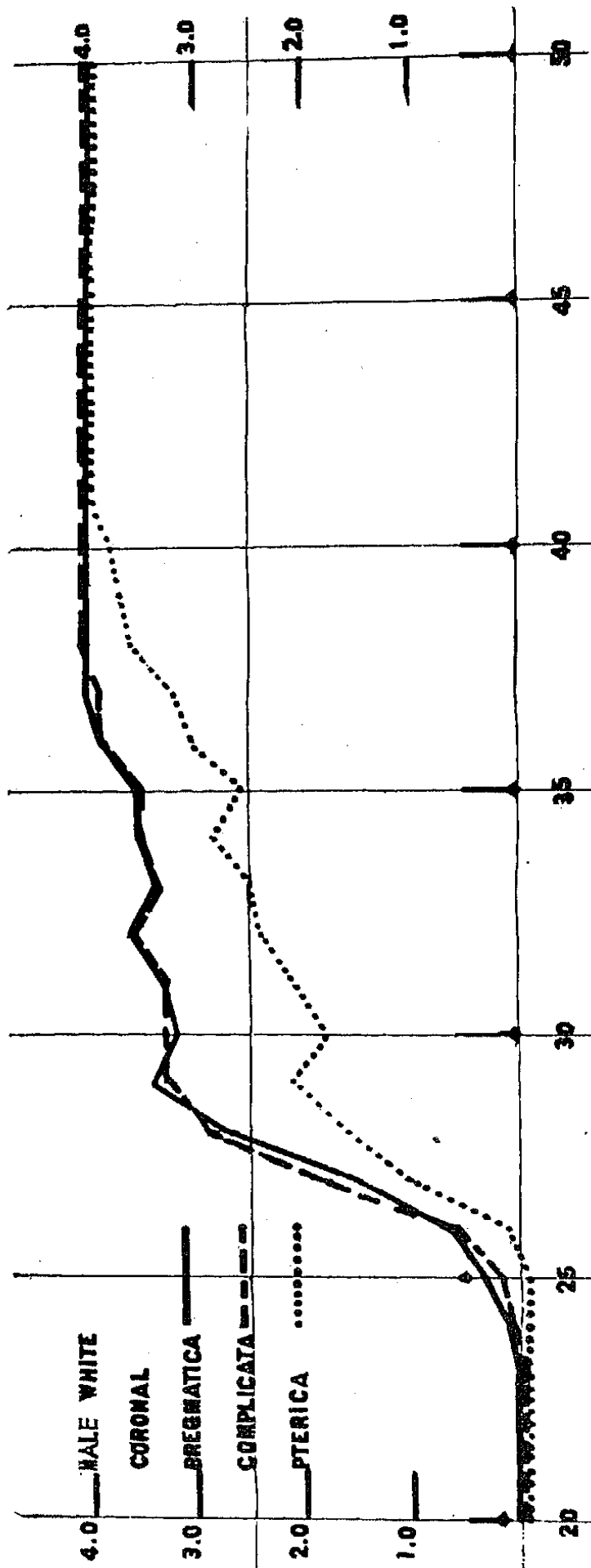


FIG. 4. Endocranial closure progress in the coronal suture.

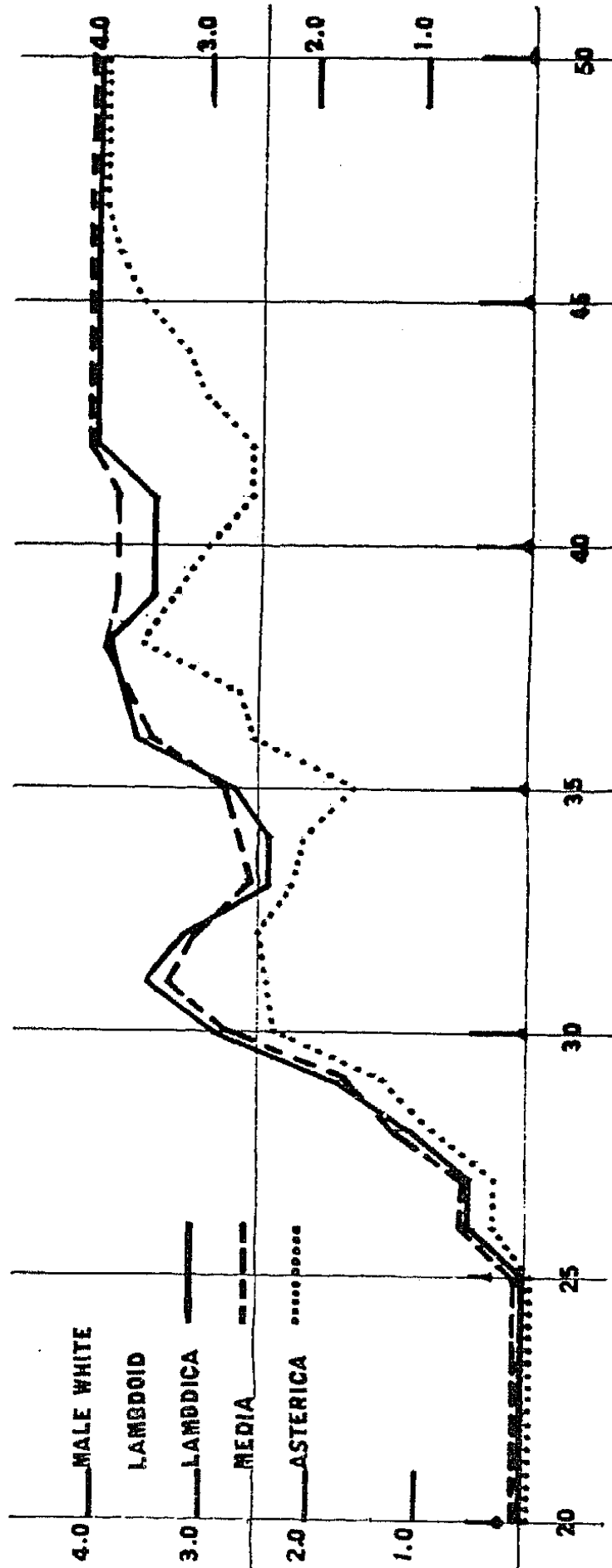


FIG. 5. Endocranial closure progress in the lambdoid suture.

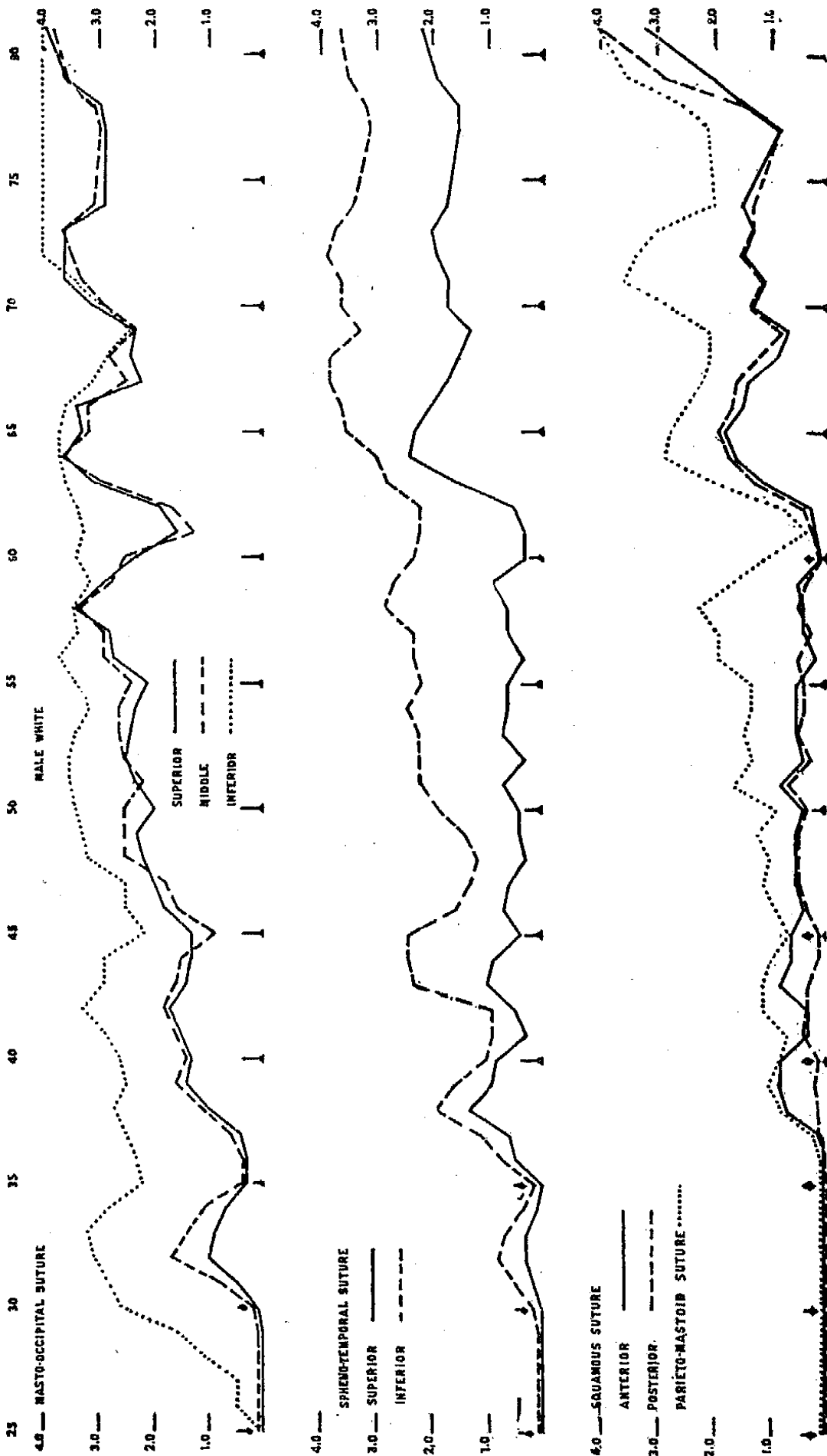


FIG. 6. Endocranial closure progress in the circum-meatal sutures.

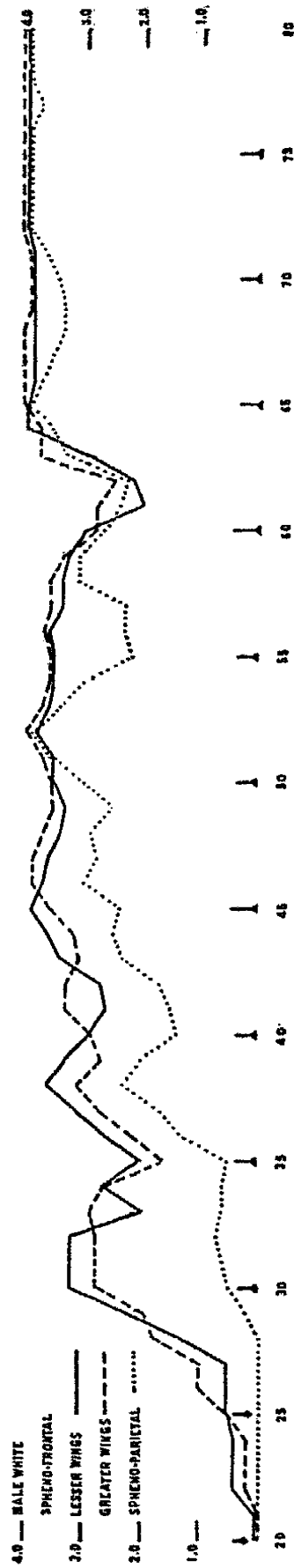


FIG. 7. Endocranial closure progress in the accessory sutures.