STUDIES IN CALIFORNIA PALEOPATHOLOGY

III. ENLARGED PARIETAL FORAMINA - THEIR MORPHOLOGICAL VARIATION AND USE IN ASSESSING PREHISTORIC BIOLOGICAL RELATIONSHIPS

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Among the many goals of the prehistorian is the reconstruction of human relationships in time and space. The data utilized in reconstructing these relationships fall into two broad categories: cultural and biological. Cultural data include the many and diverse artifacts associated with archaeological sites, their structures, settlement patterns and all the inferences derived therefrom: subsistence and economic systems, demography, and social, religious and ideologic systems among others. Human biological relationships in prehistory, however, are limited to the skeletal remains of the members of these prehistoric populations. Here three kinds of data may be utilized: morphological, craniometric, and discrete variations or anomalies (Anderson 1968:135).

Morphological assessment entails the nonmetric description of continuous characteristics, often to the point of making population comparisons solely on typological grounds (e.g., Gifford 1926). For the most part this technique has been abandoned by the majority of contemporary physical anthropologists. Craniometric evaluations are grounded in the quantitative expression of absolute size and relative proportions. Population assessments based on this technique, usually employing a multivariate measure, assume that at least part of the variance observed among and between populations for these measures is genetic in origin. Because of the uncertainty of the genetic origin (or at least component) of these measures, caution should be used in their interpretation (cf. Howells 1973 and Kowalski 1972). More recently, and again primarily using a multivariate measure, discrete or nonmetric analyses have been employed in assessing biological relationships. This methodology employs a distance measure based on the presence or absence (and therefore the relative frequency) of discrete skeletal variations or 'anomalies.' Evidence indicates there is a strong genetic component to the expression of at least some of these traits and, therefore, they should be a better measure of genetic relationships than metric data. However, except for a few of these traits, our knowledge of their genetic basis in man is rather uncertain.

This paper, then, presents a series of prehistoric skulls from the San Francisco Bay region which demonstrate such a known, genetically-speaking, skeletal anomaly - enlarged parietal foramina. The possible implications of the distribution of these skulls follows their description.

The Specimens

The following abbreviations are used in the catalog numbers of the crania:

S.I. = Smithsonian Institution

S.A. = Stanford Anatomy

LSJM = Leland Stanford Junior Museum

LMA = Lowie Museum of Anthropology

Smithsonian Institution (descriptions and measurements courtesy of Dr. J. Lawrence Angel): two specimens from the Ponce Mound (also called Castro Site, et al., 4-SC1-1) near Palo Alto, CA., collected and donated by Harold Heath in 1913.

S.I. #276981 - an adult male ca. 24 years old, with closure of the sagittal and lambdoid sutures; there is premature synostosis but little or no deformation; Angel notes there are "two beautiful, symmetrical enlarged foramina looking like the eyeholes in a Shang dynasty bronze mask;" (Plate 1).

S.I. #276982 - a child ca. four years old with "gross cranial deformation skewing the vault from lower right toward upper left and complete premature fusion of coronal, right upper lambdoid, and sagittal sutures;" the enlarged foramina appear as two slits "looking like scars actually, but obviously not traumatic." (Plate 1).

Stanford University: nine skulls from the Ponce Mound site, eight collected in the 1930's by Prof. Meyer of the Department of Anatomy, Stanford University School of Medicine (hence the S.A. designation), and one donation (LSJM #75.1055) by Mr. Victor Buenzle in 1975; all skulls are presently in the Department of Anatomy, Stanford University, except crania S.A. 83 and LSJM #75.1055 which are in the anthropology collections of the Leland Stanford Junior Museum.

S.A. 22 - adult, female (?), with all major cranial vault sutures intact; there is moderate flattening bilaterally at the junctions of the occipital, temporal, and parietal bones; the foramina are large, open, oval structures; (Plate 2).

S.A. 23 - adult, male (?), displaying single, small, trilobed foramen just lateral to the sagittal suture on the left; the left infratemporal region is missing and there is slight crushing with distortion; the right lower 1/3 of the coronal and the middle 1/3 of the sagittal sutures are closed; there is slight lambdoid flattening and mild vault keeling; (Plate 2).

S.A. 24 - adult, female, with metopic suture nearly intact except for short superior segment; posterior 1/3 of the sagittal suture is fused; several small osteomata appear on the vault; there is slight lambdoid flattening and bilateral flattening as in S.A. 22; the foramina are large oval defects: (Plate 2).

S.A. 25 - adult, male(?), with fused coronal, sagittal and lambdoid sutures and mild vault keeling; there is slight lambdoid flattening and the bilateral flattening noted in S.A. 22 and 24; on

the left, two, small (< 2mm) foramina are present in a single dimpled depression separated by a thin bridge of bone; a partially closed slit extends laterally from the depression; the right parietal foramen has a slit extending 2.5 mm laterally and a remnant of a slit medially - all in a slight dimpled depression; another fragment of the original enlarged foramen on the right appears as a dimple slightly inferior and medial to the main extant foramen; (Plate 2).

S.A. 26 - adult, male(?), with fusion of middle 1/2 of the lambdoid and the anterior 1/2 of the sagittal sutures; there are open, oval foramina of unequal sizes; (Plate 3).

S.A. 49 - adult, female, with fusion of the right half and part of left portion of the coronal, the anterior sagittal, and the medial aspect of the left half of the lambdoid sutures; there is slight lambdoid flattening and mild vault keeling; the left foramen is a small dimpled depression with a thin plate of bone nearly closing the orifice; the right foramen is generally oval in shape but the superolateral aspect has narrowed due to an ingrowth of bone from the inferolateral border of the foramen, giving the foramen an outline appearance of a curve-necked gourd; (Plate 3).

S.A. 54 - adult, male; the left foramen is small with a slit extending laterally from the superior border; remnants of the right foramen appear as two small dimples, both open in a slight depression; all sutures are intact except for the extreme posterior end of the sagittal which is fused; (Plate 3).

S.A. 83 - child of approximate dental age of 12 years (all four permanent second molars just reaching occlusal plane); the skull, showing evidence of partial cremation, is warped such that there has occurred a continuous separation along suture lines beginning with the left half of the coronal and continuing along the sagittal and the right half of the lambdoid, resulting in the occipital, left parietal and left temporal forming a separate unit of the cranial vault; all vault sutures are intact; there are large accessory ossicles at the parietomastoid sutures bilaterally; the enlarged left parietal foramen is roughly rectangular in shape while the oval right foramen shows slits at its medial and lateral extremities due to the progress of closure of the foramen; the associated post-cranial material is unremarkable; (Plate 4).

LSJM #75.1055 - adult, female, ca. 20 years old (basilar suture partially closed, third molars erupted with mild occlusal wear); a metopic suture is wholly intact; there are large accessory ossicles at the parietomastoid sutures bilaterally and a single accessory ossicle ca. 1.5 cm in diameter in the midportion of the sagittal suture; the foramina are large, oval defects; there is bilateral tympanic plate dehiscence; (Plate 4).

Lowie Museum of Anthropology: two skulls from 4-CCo-138, a Late Horizon site from Contra Costa Co., CA., collected by E.N. Johnson in 1937.

LMA #12-5575 - adult, female(?); although the sagittal suture is nearly obliterated, approximately 4 cm posterior to bregma a remnant of it deviates to the right and continues 3.5 cm to end in the right

parietal about 2 cm above the medial 1/3 of the right parietal foramen; the lateral aspects of the lambdoid suture are partly fused, and the medial part of the lambdoid nearly or completely fused and appear to terminate in the middle of the inferior borders of each foramina on their respective sides rather than in the midline at the posterior terminus of the sagittal suture; portions of the coronal suture are beginning to fuse; the foramina are extremely large, oval structures; (Plate 4).

LMA #6246 - adult, female, 52-59 years old (after Gilbert and McKern 1973) the sagittal suture is completely obliterated giving the skull a moderately keeled appearance; the lambdoid suture is completely and the coronal nearly obliterated; a shallow groove connects the large, oval parietal foramina across the midline, immediately below which is a prominent, smoothly rounded bump 2 cm in diameter; the occipital squama has a slight oval depression (4 x 2.5 cm) with a central area of fine osteoporotic bone; (Plate 4).

Dimensional aspects of the foramina are found in Table 1.

TABLE 1

Measurements of enlarged parietal foramina
(All measurements in mm except axis angle)

Specimen #	Greatest diameter		Maximum diameter perpendicular to greatest diameter		Axis angle with horizontal		Medial corner distance to midline		Lower border distance above lambda	
	L	R	L	R	L	R	L	R	L	R
S.I. 276981	18.2	21.1	10.8	13.2	+40°	+47°	9.5	8.0	20.0	17.0
S.I. 276982	18.8	15.9	3.0	1.5	+15°	-16°	13.0	17.0	7.0	0
S.A. 22	12.5	13.9	7.6	7.2	+35°	+40°	14.5	13.7	19.0	16.0
S.A. 23	4.2	--	2.8	--	+80°	--	on mid-line	--	33.6	0
S.A. 24	16.6	13.6	8.8	8.3	+30°	+35°	8.1	9.0	8.1	9.8
S.A. 25	--	2.4	--	2.2	--	+10°	12.5*	21.0	15.0	19.0
S.A. 26	8.0	17.9	4.6	10.2	+30°	+15°	11.5	10.5	13.6	9.3
S.A. 49	2.4	13.4	1.2	4.2	+35°	+40°	11.4	13.8	9.5	7.8
S.A. 54	2.4	--	2.0	--	+35°	--	10.7	--	39.2	
S.A. 83	20.4	12.8	7.5	5.3	+35°	+30°	12.0	16.6	6.0	8.0
LSJM 75.1055	17.1	25.3	11.5	16.6	+10°	+18°	15.5	8.5	16.0	10.0
LMA 12-5575	35.5	37.4	26.9	28.0	+10°	+10°	10.0	5.0	n.d.	n.d.
LMA 12-6246	14.7	15.9	10.0	8.5	+5°	0°	7.3	7.3	n.d.	n.d.

n.d. = not determinable

-- = feature missing

* = distance from medial corner of depression

Discussion

Enlarged Parietal Foramina

In the normal cranial vault there exist, either paired or single, a number of emissary veins which pass through various foramina in the cranial wall to establish communications between intracranial venous sinuses and extracranial veins. Among these is the parietal emissary vein which passes through the parietal foramen to connect the superior sagittal sinus with scalp veins; occassionally a branch of the occipital artery is also carried along. The parietal foramen in the normal state is usually 1 mm or less in diameter and located a few centimeters above lambda just lateral to the sagittal suture; it may appear as a paired or single opening, may be absent altogether, or be closed but still discernible (Newton and Potts 1971; Pendergrass et al. 1956; Warwick and Williams 1973). Very rarely, however, the parietal foramen may not ossify normally and result in a round or oval defect that may be several centimeters in diameter. This cranial anomaly is termed enlarged parietal foramina (foramina parietalia permagna).

The early anatomical literature gave mention of enlarged parietal foramina and in 1865 Turner published the first adequate description. The anomaly has also been called the "Catlin mark" after Goldsmith (1922) published an account of 16 cases in five generations of the Catlin family. Lother (1959) has described a series of five cases in two generations, thus helping establish the trait as familial and hereditary in origin. In his catalog of inherited phenotypes in man, McKusick (1975) lists the trait as an autosomal dominant and examination of the existing pedigrees mentioned (plus Miller and Keagy 1956) supports this. In those pedigrees where the pattern of inheritance does not seem to hold, the most reasonable explanation is there are individuals in which the originally enlarged parietal foramen has closed to such an extent that it cannot be detected radiographically or by palpation. That this happens with some regularity can be seen in the present series and surmised from the variation seen in other examples already cited or in Pepper and Pendergrass (1936) and Keats (1973).

Enlarged parietal foramina have been classified as atrophic (hypoplastic) changes in the cranial vault (Newton and Potts 1971:209) and are felt to be secondary to faulty ossification of the parietal fontanelle (also called the sagittal or third fontanelle [Warkany 1971:891]). This latter structure is very rarely mentioned in anatomy texts but is situated along the sagittal suture about 2/3 to 3/4 of its length posteriorly, i.e., at the pars obelica of the sagittal suture. Early in fetal life, and occasionally following birth (Goldsmith 1922; Miller and Keagy 1956; Murphy and Gooding 1970; Pendergrass and Pepper 1939), the parietal fontanelle forms a large single opening along the sagittal suture and later divides into two parts by a bridge of bone growing along the midline. The site of the divided parietal fontanelle is the same as normal parietal foramina. The result is two, roughly symmetrical, bilateral parietal defects just lateral to the sagittal suture and a few centimeters above lambda. The foramina often persist as large defects throughout life, or may partially or completely close; in the

latter instance there will usually be some gross manifestation of the remnant which may or may not be detectable except in dry, preserved crania. Warkany (1971: 891) provides an excellent description of this ossification sequence.

For the osteologist who handles dry bone on a regular basis, this anomaly is easily recognized by its characteristic appearance and location, although it may very rarely occur in the anterior 1/3 of the parietal bone (Epstein and Davidoff 1953:67). For the radiologist and others who must differentiate this phenomenon in the living individual from other, more serious possibilities, the differential diagnosis includes (after Pendergrass et al. 1956; Silverman 1968; Warkany 1971):

meningocoele

epidermoidoma

infection (yaws, syphilis)

histiocytosis X

dysostosis (cleidocranial) of the cranial bones

osteoporosis circumscripta

renal and celiac rickets

primary or secondary metastatic neoplasm

surgical defects (burr holes or trephine openings)

multiple myeloma.

As the present series demonstrates there is a rather wide range of variation in size and general morphology of enlarged parietal foramina. The foramina thus may present as large, oval defects which are easily detectable (e.g., LMA 12-5575, S.I. 276981), smaller foramina but still quite distinctive (e.g., S.A. 26, S.A. 49), or former openings which have nearly or completely closed (e.g., S.A. 25, S.A. 54). The foramina may appear as oval to round structures, rectangular openings, slits, dimpled depressions of irregular shape, or as irregular-shaped holes; the range of shape variation reflects to a great extent the degree of closure the previously open foramina have undergone.

In those specimens where the foramina are still patent, the edges are generally smooth, rounded, and give a bevelled appearance. The bevelling is present on both the endocranial and exocranial surfaces, with the latter usually showing a wider bevel space. The inside/outside nature of the bevelling should help to distinguish the phenomenon from trephine openings. Angel (personal communication) has also noted that "if one visualizes an interosseous membrane, as in the obturator foramen, formed from pericranium fusing with endocranium the edge is what one would expect." Angel also comments that "there are medial corner grooves...which ought to be for the emissary veins."

As with many other skeletal anomalies, enlarged parietal foramina are often associated with other defects (O'Rahilly and Twohig 1952; Pendergrass et al. 1956; Warkany and Weaver 1940; see Warkany 1971 for general review). Among the most frequently cited are cleidocranial dysostosis and metopism. The inability to associate postcranial material with the majority of the crania from the Ponce Mound lessened our attempt to detect the former association; in those crania with known postcranial material no abnormal clavicles were found. However, two skulls (S.A. 24 and LSJM 75.1055) manifest a persistent metopic suture. In none of the cases reported in the literature, though, was mention made of an interesting association found in the present series.

Since the basic defect in enlarged parietal foramina lies in faulty ossification of the parietal bones, one might expect to see abnormal ossification in other skeletal parts as well, particularly in nearby regions of the cranium. In the present series of 13 skulls, 10 manifest partial or complete closure of one or more major cranial vault sutures (i.e., coronal, sagittal, lambdoid). See Table 2. We must be careful, though, and recognize that some of these instances of suture closure merely reflect the biological age of the individual concerned. One difficulty with the present series, already noted, is the lack of associated postcranial material which would allow aging via the pubic symphysis. Thus, although we cannot age some of the individual skulls, and thereby state whether vault suture closure is premature or not, we can make some tentative predictions.

Premature closure of the major vault sutures produces characteristic vault deformities. Thus, craniostenosis of the sagittal suture produces scaphocephally or a skull with a "keel-shaped" vault with an osseous prominence where the obliterated suture had been. The portion of the parietals adjacent to the obliterated sagittal suture slope away and are flatter in appearance than the usual smoothly rounded vault; this is produced by the lateral pressure of the expanding brain mass. Early closure may occur at any time, but the later the craniostenosis occurs the less severe is the deformity. In the series under discussion, four of the crania that cannot be aged (S.A. 23,25,49; LMA 12-6246) show a mild or moderate keeling associated with complete or partial closure of the ectocranial aspect of the sagittal suture. I submit these as examples of partial or complete craniostenosis of the sagittal suture, albeit late in terms of the biological age of the specimens concerned.

The two Smithsonian skulls, one aged ca. 24 years, the other ca. 4 years, both show premature suture closure. In the infant this has resulted in the marked skewing of the vault (known as plagiocephaly) noted by Angel in the above description. With complete closure of the sutures in the 24 year old, we presume, as Angel notes, this individual represents an example of craniostenosis without deformation. Of the remaining crania, the degree of suture closure is compatible with the known age of the individual. Of our total series, then, six are considered to show an association of enlarged parietal foramina with craniostenosis of one or more major vault sutures, the amount of deformation produced ranging from severe to mild.

TABLE 2

DEGREE OF VAULT SUTURE CLOSURE IN CRANIA WITH ENLARGED PARIETAL FORAMINA

Specimen #	Age, in years*	Degree of suture closure** Sagittal	Coronal	Lambdoid	Appearance of foramina
S.I. 276981	ca. 24	C	O	C	large, open ovals
S.I. 276982[1]	ca. 4	C	C	P	open slits
S.A. 22	n.d.	O	O	O	large, open ovals
S.A. 23[2]	n.d.	P	P	O	small, round
S.A. 24	n.d.	P	O	O	large, open ovals
S.A. 25[2]	n.d.	C	C	C	partly closed
S.A. 26	n.d.	P	O	P	large, open ovals
S.A. 49[2]	n.d.	P	P	P	partly closed
S.A. 54	n.d.	P	O	O	partly closed
S.A. 83	ca. 20	O	O	O	large, open ovals
LSJM 75.1055	ca. 12	O	O	O	open, rectangular
LMA 12-5575	n.d.	C	P	P	large, open ovals
LMA 12-6246[2]	ca. 55	C	C	C	large, open ovals

* -n.d. = not determinable

** - C = closed
P = partially closed
O = open

1 - cranium deformed, i.e., plagiocephaly

2 - mild to moderate vault keeling

We should also note that the degree of suture closure, whether premature or not, is not associated with any particular degree of closure of the enlarged parietal foramina. The examples of craniostenosis are seen with large, open foramina or slits, while those crania with presumably normal suture closure have large open foramina or ones which are nearly closed. If there is some direct association between craniostenosis and enlarged parietal foramina, then it apparently does not involve the timing of the ossification processes.

Biological relationships in Central California

We noted at the outset of this paper that the reconstruction of prehistoric human biological relationships is essentially limited to the analysis of three kinds of data: morphologic, craniometric and nonmetric. Suchey (1975) has recently summarized these studies as they relate to prehistoric Central California. Actually, a fourth data set is available but, because of data preservation or the rarity of known data in this set, it is virtually unknown or unused in the context of assessing prehistoric biological relationships. We are referring here to traits that are known to be under strict genetic control with little or no environmental component in their expression. Data in this set include the myriad array of blood groups, serum proteins, genetic anomalies of various organ systems, and others. The lack of preservation of these 'soft tissue' indicators of underlying genetic structure is an obvious problem. But the skeleton contains numerous expressions of this sort which could potentially be used to solve the problem of prehistoric biological relationships. However, unlike the blood group and serum protein data which are seen as part of the broad range of normal human biological variation, these skeletal 'anomalies' are exceedingly rare and, unless one is dealing with an extremely localized problem, they are likely to be of little use. Fortunately this is the problem we are concerned with here.

The existence of a relatively large series of crania exhibiting enlarged parietal foramina from the greater San Francisco Bay region and adjacent interior is part of the lore among archaeologists who have worked in this region (Drs. Bert Gerow and Robert F. Heizer, personal communication). However, because of the lack of consistent reporting of this kind of material in such a way that it could be readily accessible to archaeologists and physical anthropologists, the implications of finding two groups of crania with this anomaly, of know pattern of inheritance, has not been made as strongly as it could have. Indeed, knowledge of the existence of this material was probably more widespread among the medical profession than among anthropologists through the publication of one of the Smithsonian crania (no. 276981) by Pepper and Pendergrass in 1936.

During a survey of New World skeletal material by Don R. Brothwell in the mid-1960's there was the first mention of the implications of this anomaly in assessing biological relationships. But here the record becomes rather confused and certainly incomplete. Brothwell notes:

> In discussing the inheritance of this condition in the living, Pepper and Pendergrass (1936) figure another ancient case, in this instance from a prehistoric Amerindian burial mound in Palo Alto, California....two further cases of this anomaly were noted from the Palo Alto site (one now in the Lowie Museum, Berkeley, California, and the other in the Smithsonian Institution, Washington). (Brothwell and Powers 1968:187-188)

The additional crania Brothwell mentions were found during his New World survey. We do not know, in fact, whether the specimen he 'found' in the Smithsonian was the same one (no. 276981) reported by Pepper and Pendergrass (1936) or if it was the second Smithsonian cranium (no. 276982) brought to my attention by J. L. Angel. Presumably it was the latter situation since Brothwell states that "two <u>further</u> cases of this anomaly were noted" and since he apparently was aware of the article by Pepper and Pendergrass (1936) which gives the catalogue number (276981) of the Smithsonian cranium displayed. However, the 'further case' housed in the Lowie Museum is apparently not from the Palo Alto site (a search of museum records and skeletal material has failed to disclose it) but is probably one from CCo-138, on the other side of San Francisco Bay and to the northeast in the interior some 50 miles away. And there is not one cranium in the Lowie Museum with this anomaly, but two--both from CCo-138. It is unfortunate, too, that Brothwell did not know of the existence of the series of crania housed at Stanford University which were from the same Palo Alto site mentioned. But even though the extant series from both sites was only partially known to him, Brothwell recognized the potential importance of the material:

> Although there is no certain evidence of the contemporaneity of these Amerindian cases, the proximity of the burials strongly suggests that we might have here prehistoric evidence of a marked anomaly influencing a family group (Brothwell and Powers 1968:188).

Had Brothwell known of the additional nine crania from Palo Alto, the certainty of having identified a family group would have been overwhelming. And had he known, or correctly identified, the Lowie Museum material as coming from an additional site in the interior region adjacent to San Francisco Bay, I feel certain he would have immediately grasped the implications of the distribution of the anomaly.

That we are dealing here with a single biological lineage can be argued from the rarity of the phenomenon and its localized distribution. As so many authors have noted, enlarged parietal foramina are rare hereditary, congenital anomalies. Hardly more than 100 examples have been reported in the medical and anatomical literature since Turner's first full exposition of the subject in 1865 and the vast majority of these represent clusterings in family groups. It apparently arises by spontaneous mutation and, because of its autosomal dominant pattern of inheritance, quickly spreads through succeeding generations. Since eleven of the present series of thirteen crania all derive from a single site we can probably say that they represent

a single prehistoric biological lineage. Because of the haphazard nature of the way the Palo Alto series was collected, however, we cannot state emphatically that this was the case.

The Palo Alto site (variously known as the Ponce Mound, Castro Mound, Mayfield Site, site 357, and SCl-1) had been a favorite local collection site for artifacts and skeletal material for nearly three-quarters of a century until its final burial beneath a recent construction project. In general, the Palo Alto material cannot be placed in any exact archaeological context because of its collection by untrained amateurs. In most cases we cannot even definitely associate postcranial remains with the crania. Despite the lack of good archaeological control for these specimens, it is generally recognized that the Ponce Mound dates from the Middle and Late Horizons of the Central California archaeological sequence.

Beardsley (1954) notes two occupation levels of the Ponce Mound site: component A and component B. Ponce A is known from burials located at depths of 12 to 39 or 52 inches and is felt to represent Phase I of the Late Horizon. Ponce B, of Middle Horizon context, is known from burials 39 or 52 or 93 inches in depth; in general, B component deposits are below a depth of 60 inches. The majority of the Stanford crania in this series were collected at the same time as other material presently housed in the Leland Stanford Junior Museum. Some of this latter material has brief original field notations which mention "specimen found at a depth of 3 feet" or merely "45 inches." If this, then, represents the general depth at which all or most of the Stanford Anatomy material was located, we may tentatively say this material is from component A and, therefore, is of Phase I, Late Horizon origin. This is partially supported by the fact that the Hotchkiss site (CCo-138) dates from Middle Phase I through Phase II of the Late Horizon (Bennyhoff in Cook and Heizer 1962). The lack of associated artifacts and/or archaeological control, however, limit the security of our dates for the Stanford Anatomy material.

We have, then, a series of thirteen crania, probably all dating from the Late Horizon, which manifest a very rare congenital skeletal anomaly of known autosomal dominant inheritance (McKusick 1975). They probably represent at least a portion of a biological lineage or "family." Obviously we cannot even begin to construct a pedigree, but that does not concern us so much here. Our concern and interest in this series stems from the fact it represents individuals from two widely separated sites in the San Francisco Bay area and adjacent interior; the Ponce or Castro Mound (SCl-1) from near Palo Alto in the southwest bay region and the Hotchkiss Site (CCo-138) to the northeast in the interior. That there was <u>some</u> degree of cultural continuity and contact in the greater San Francisco Bay region prehistorically has been noted by many authors (see general reviews in Heizer 1964, Frederickson 1974, Gerow and Force 1968, and Beardsley 1954) although the diversity among sites from various regions has been increasingly emphasized.

As noted above, Suchey (1975) has summarized all previous works on biological relationships among prehistoric Central California Indians and has also given us the most comprehensive study to date of this problem via her analysis of non-metric traits of the cranium. The real significance of this study, I believe, lies in its explicit recognition of the problems in interpreting biological distances based on non-metric data. Suchey notes (1975:127):

> A major question precipitated by this analysis was the extent to which environmental factors as well as genetic factors were being reflected in the MMD (based on the non-metric cranial traits). The hypothesized convergence of the Central California and Southern California coastal samples could only have been caused by natural selection or an environmental effect on the threshold. I suspect that it may be the latter since I find it difficult to see how these accessory sutures, foramina, and bony tori can be related to fitness, mate selection, or reproduction. Also certain similarities in the diet of these coastal samples seems to point in this direction.

The implications of this statement are great, especially when most biological distance studies implicitly assume that the 'distance' between two or more groups is some measure of their genetic distance. Often this assumption is quite explicitly stated, as for example in the following:

> The emphasis on discrete non-metric variants in this study underlies the identification of genetical patterns through morphological comparisons. Such traits have been found to be useful in delineating biological affinities among skeletal populations. (Cybulski 1975:17)

Until further studies are done which address themselves to the problems alluded to by Suchey, we should be very careful about statements which imply genetic relationships. And that is the advantage of using data such as enlarged parietal foramina. For although the data is very rare it is genetic in origin, and can be used, with caution, for saying something about genetic relationships in restricted localized areas. And so, for such a focal area in Central California, we have now fairly conclusive evidence that there was also direct biological contact, and not merely the mutual exchange of cultural goods between contiguous groups.

Was there really direct contact among the peoples of the Ponce and Hotchkiss sites? Obviously, we cannot say for certain. There may have been, as with the passage of trade goods "down the pike," exchange of genetic material between contiguous groups. But the lack of crania exhibiting enlarged enlarged parietal foramina in intervening populations weakens this idea. The original focus of the anomaly was probably in SCl-1 with subsequent diffusion of the gene outward. Perhaps a trading party or other group from SCl-1 made contact with the inhabitants of CCo-138 and the gene was then imparted into

the latter group. We could imagine any number of similar scenarios, all of which could be equally reasonable. But to do so would belabor the point.

The simplest explanation here, I think, is the most reasonable: there was direct biological contact between the populations, probably individuals from SCl-1 contacting those from CCo-138 at or near the Hotchkiss site itself. Whether there was a subsequent marriage or merely a fleeting relationship we cannot say; nor does it matter for the results would have been the same.

Summary and conclusion

A series of thirteen crania exhibiting a diverse pattern of variation in the expression of a hereditary, congenital skeletal anomaly has been presented. The crania with enlarged parietal foramina represent material from two widely separated sites in the San Francisco Bay region of California. Because of the rarity of this anomaly, its autosomal dominant mode of inheritance, and its focal appearance at two sites which are known to share some cultural material, it has been argued that we have represented here a portion of a prehistoric biological lineage and probably evidence for direct biological contact between the two sites which are some fifty land miles distant from one another.

It is important that archaeologists be cognizant of this kind of skeletal anomaly, including its variable expression, so they can alert interested osteologists for further analyses as well as recognizing for themselves the potential implications such material may have for their own archaeological reconstructions and interpretations.

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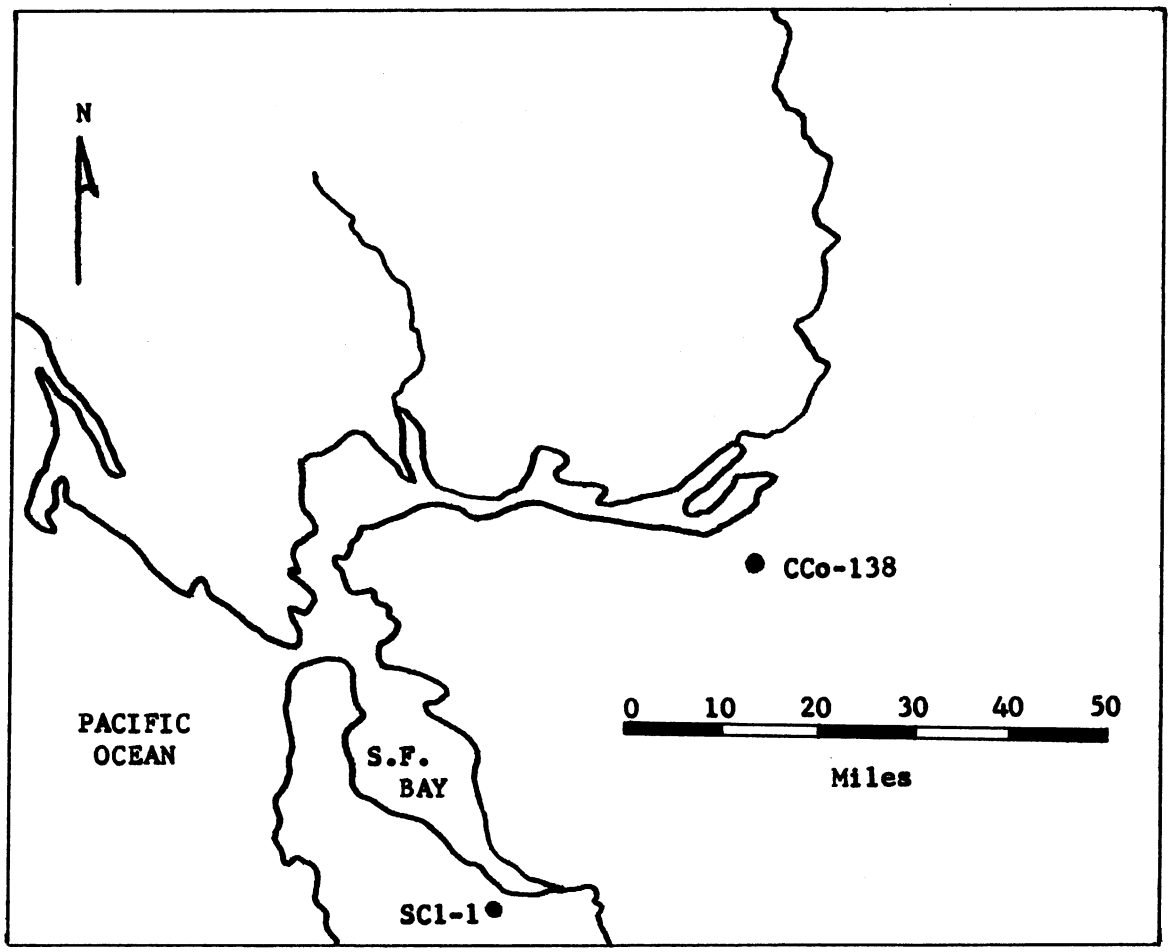


Figure 1: Geographic locations of SC1-1 (Ponce Mound) and CCo-138 (Hotchkiss Site)

Plate 1: Crania showing enlarged parietal foramina. (Photo courtesy of Dr. J.L. Angel, Smithsonian Institution, Washington, D.C.)
Left: S.I. #276981; right: S.I. #276982 (note skewing of cranial vault)

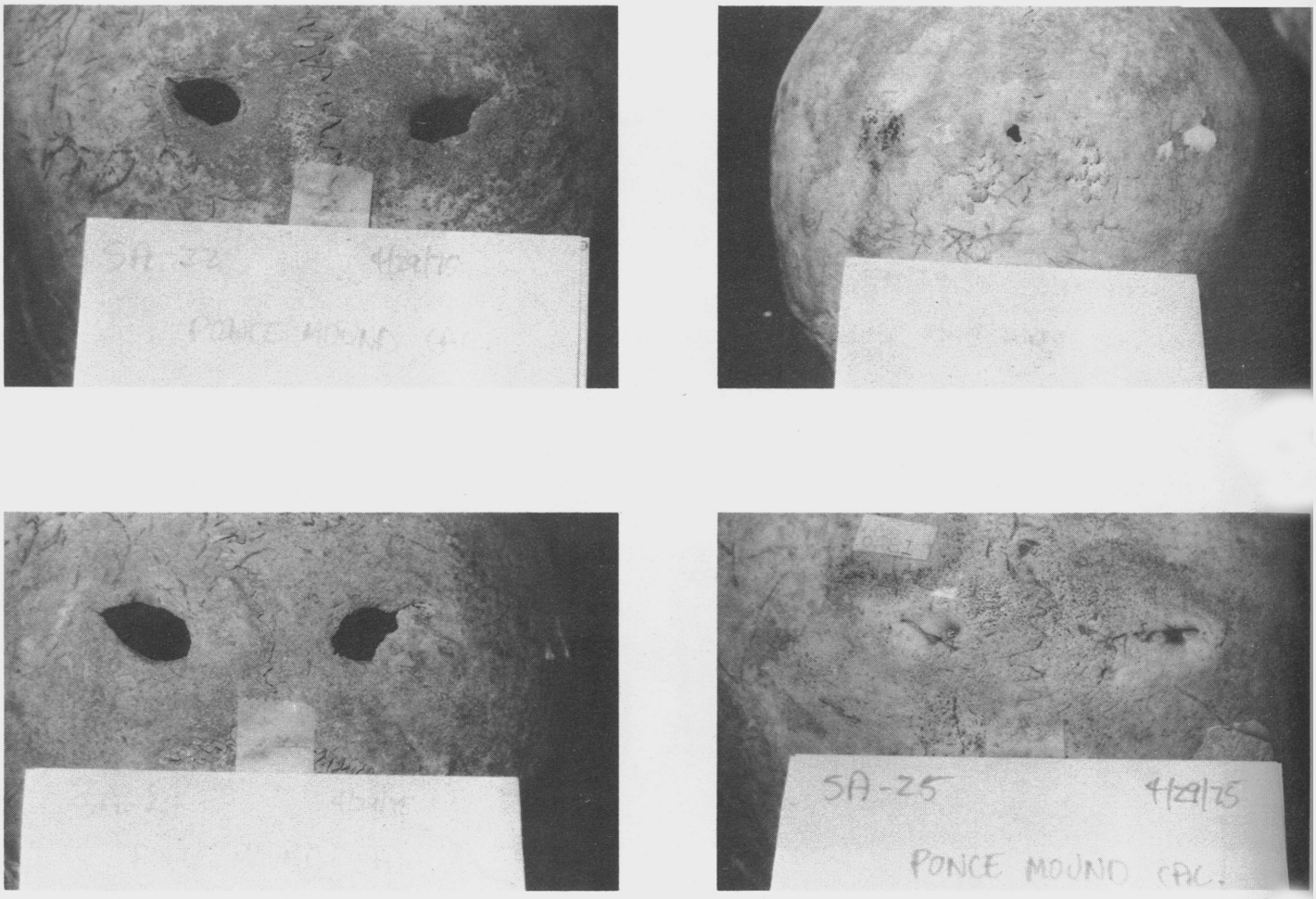
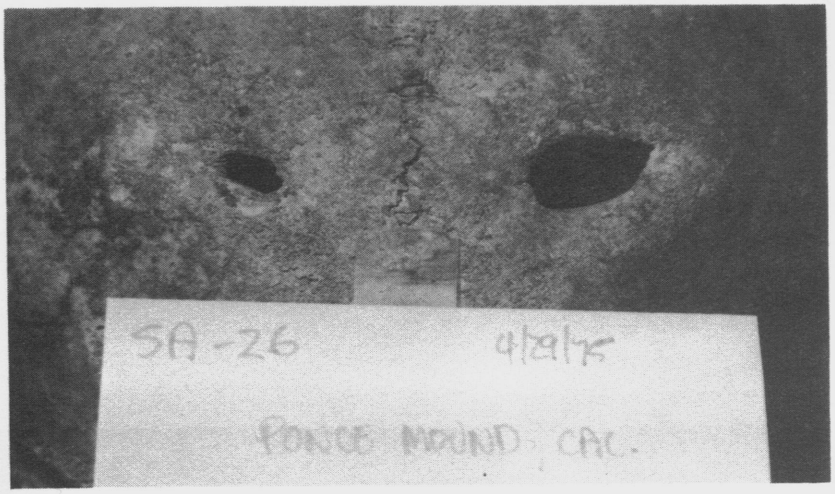
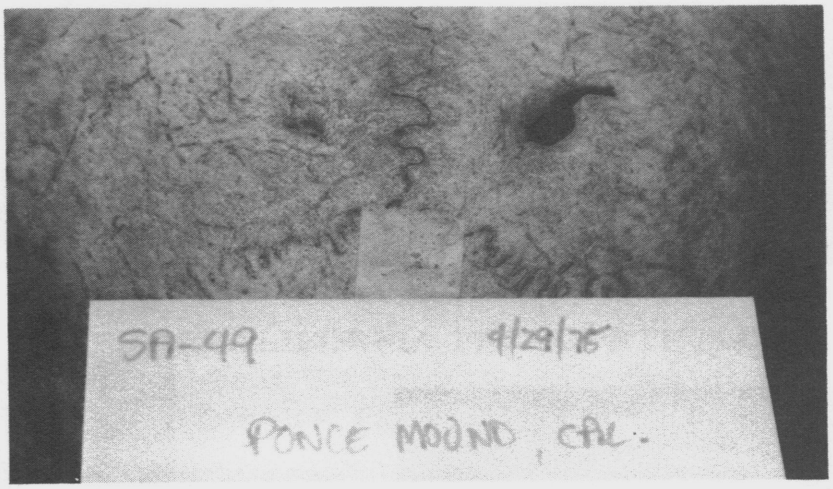


Plate 2: Crania showing enlarged parietal foramina. Top row: left, S.A. 22; right, S.A. 23. Bottom Row: left, S.A. 24; right, S.A. 25.





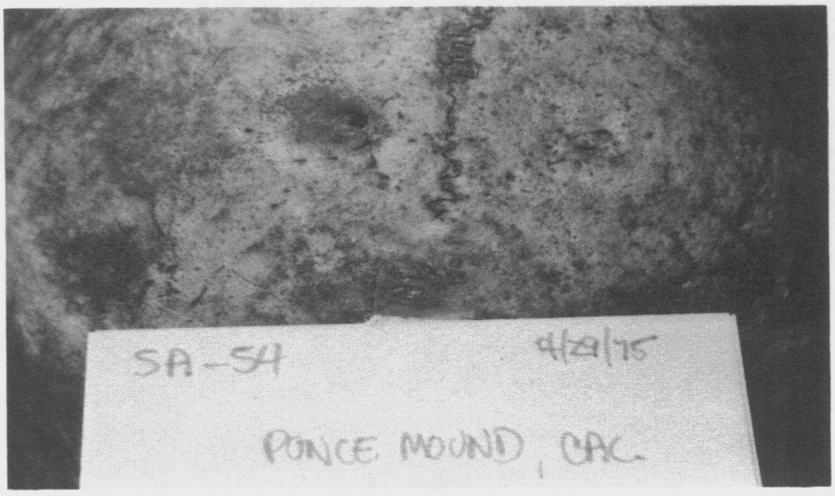


Plate 3: Crania showing enlarged parietal foramina. Top: S.A. 26; middle: S.A. 49; bottom: S.A. 54.

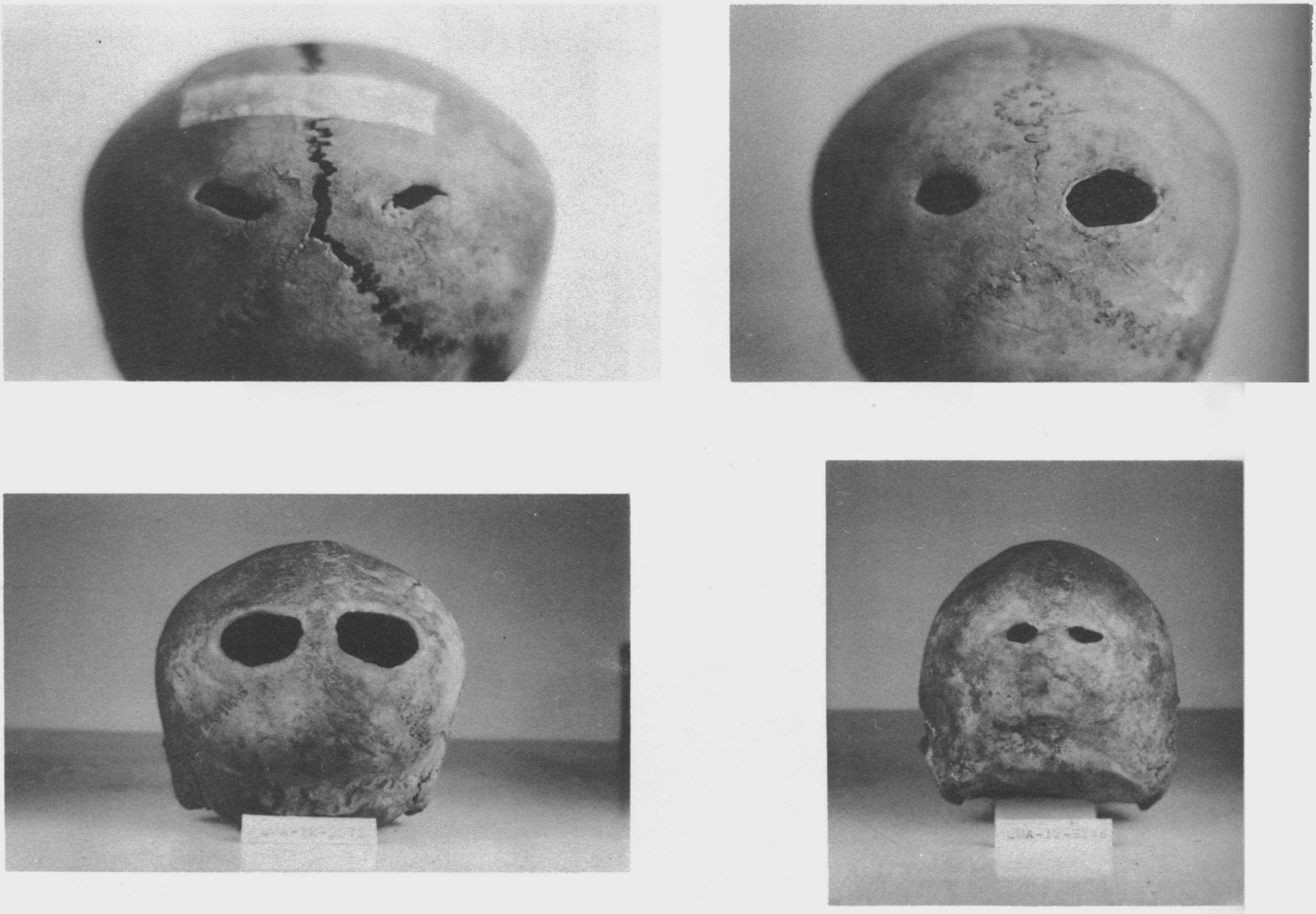


Plate 4: Crania showing enlarged parietal foramina. Top row: left, S.A. 83; LSJM #75.1055. Bottom row: left, LMA 12-5575; right, LMA 12-6246.