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The Lateral Craniographic Method of Facial Reconstruction

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ABSTRACT: Fifty-four lateral cephalographs with clear soft tissue profiles of American Caucasians (17 males, ages 14 to 36; 37 females, ages 14 to 34) were traced and measured to establish the ranges and means of midline soft tissue depths and facial angles. With these data it is possible to reconstruct "approximate" profiles over X-ray tracings of unidentified skulls. The lateral craniographic method of facial reconstruction requires four steps: (1) a cephalometric analysis is first made to determine the facial proportions and individual skull type; (2) the mean soft tissue thicknesses and angles are then plotted against the basic midline anthropometric points to establish the average dimensions of the nose, lips, and chin; (3) the points are connected and "harmonized" in accordance with the known anthropological data (sex, age, race); and (4) the profile is finally "humanized" by adding tone, a stylized eye, hair patterns, age lines, and any other features that can be determined from an anatomic examination of the skull. The validity of the method is illustrated with three study cases of living orthodontic patients.

KEYWORDS: physical anthropology, facial reconstruction, X-ray analysis, cephalometry, graphic illustration

Forensic facial reconstruction is the scientific art of visualizing faces on skulls for the purpose of individual identification. Toward this admittedly lofty goal several procedures have been developed using both graphic and plastic techniques. Sculptural reconstruction in clay, plasticine, or wax directly on the skull is the most popular and most publicized method and will not be described here. The leading proponent of this technique in the United States is Betty Pat Gatliff and interested forensic artists are referred to her series of instructional papers [*1-3*]. In graphic reconstructions, drawings are made on tracing paper or frosted acetate overlayed on skull photographs that have been enlarged to scale, or, as will be described in this paper, over lateral craniographs. Another promising method is photographic superimposition in which photographs of the decedent are aligned with photographs or television images of the unidentified skull using dual video cameras and other techniques [*4-8*]. This method is useful in "ruling out" suspected individuals whose skull-face correlations are anatomically impossible.

Facial reconstruction is thus a branch of forensic art (art as applied to medicolegal investigations including composite drawing, courtroom sketches, evidential illustration, and so forth) that serves as an aid, when all else has failed, in the identification of unknown and usually skeletalized remains. It is *not* a means of positive identification, and at best acts as a stimulus for generating leads in forensic science investigations. Forensic artists are quick to

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point out that a reconstruction is not intended to be a portrait but an *approximation* of the average soft tissue face to be expected from a defined skull type. The underlying skull must in some way determine the general features of individual facial form even if specific details are highly variable or even indeterminable, for example, hair patterns, eye color, nasal angulation, ear shape, and so forth. The fact that both graphic and sculptural methods have a proven success rate of approximately 50% [*9*] is a strong endorsement for the utility and validity of these unique approaches to body identification.

In this paper I shall describe a new method of graphic facial reconstruction based on tracings over lateral craniographs. This technique is not intended to supplant but to supplement existing methods and should provide a useful "blueprint" for more detailed sculptural reconstructions.

Regarding terminology, the term *reconstruction* is here considered as preferable to other synonyms such as *reproduction* and *restoration.* The term reproduction implies a perfect replication which is never the case (except in *Gorky Park*!), and the term restoration more aptly applies to soft tissue repairs on damaged but still intact remains. Facial *approximation* is perhaps a better description of the procedure but this term is not in general use.

Materials and Measurements

The first step in any type of facial reconstruction is to "flesh out" the skull using average tissue thickness marks (graphics) or markers (clay remodelling) over defined cranial points. The classical tissue depth measurements taken by His, Kollmann, and Büchly have been reprinted in Krogman [*10*] and recently updated and expanded by Rhine and Campbell [*11*]. In addition to these limited anthropometric studies, the literature of orthodontics, cosmetic surgery, and cephalometric radiography is a veritable gold mine of information on soft tissue projections [*12-26*] which cannot be neglected by the professional facial reconstruction artist. The above cited references form an essential core of craniofacial measurements and proved invaluable in developing the method to be described here.

In this study, original tissue depth data were taken from high contrast skull films that presented clear soft tissue profiles. These films were graciously provided by Dr. Arthur S. Burns and included 54 lateral craniographs of former orthodontic patients, all white Americans (17 males, ages 14-36; 37 females, ages 14-34).

For each lateral craniograph, both the skull and soft tissue outlines were traced on a sheet of graph paper ruled in 1-mm squares. The distances between the midline cranial landmarks and their equivalent soft tissue points (Fig. 1) were then measured to the nearest 0.5 mm with a dial caliper and double-checked with a simple millimetre ruler. The measurements were recorded on a specially designed cephalometric blank (Fig. 2) and finally averaged to establish the means for both male and female samples (Table 1). Each study case was numbered and placed in a folder that contained the actual X-ray, the X-ray tracing, and the cephalometric blank. When completed, these study cases provided a reference catalogue and data base for subsequent profile reconstructions.

In Step 2, the X-ray tracing of the skull outline, but *not* the soft tissue profile, was retraced on a separate sheet of graph paper using a standard X-ray light box (for professional work a drafting light table is strongly recommended). A cephalometric analysis was then made to determine the skull type, all measurements being recorded on the cephalometric blank (Fig. 2). Next, using the soft tissue means, the face was "plotted" and the points connected to produce an outline reconstruction. To compare the reconstruction with the actual profile another tracing was made in which the two were superimposed. Outline reconstructions and superimpositions were drawn for all 54 study cases and placed in their respective files. For 21 of the study cases (4 males and 17 females), Dr. Burns had included standardized profile photographs and these cases were selected for final renderings. The outline reconstruction was then retraced on a sheet of drawing paper and "humanized" by softening the line and

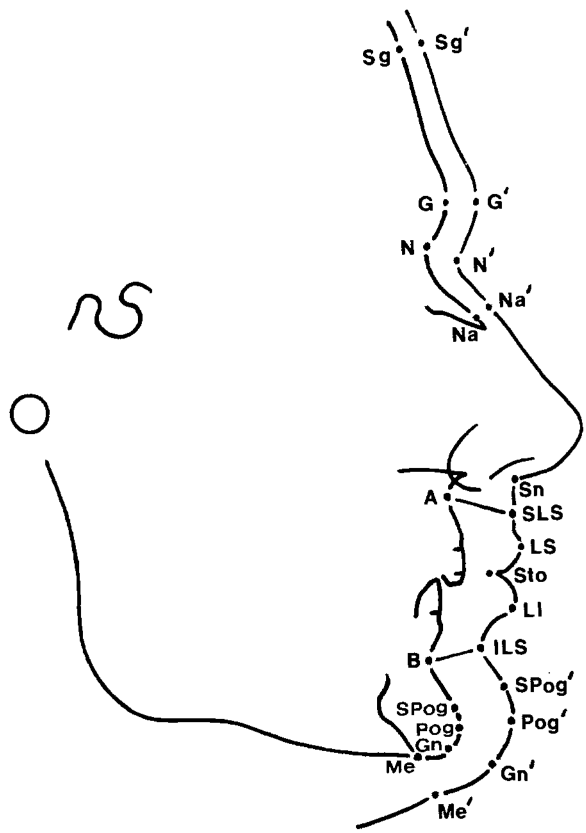

FIG. 1—*Cranial landmarks: supraglabella* (Sg), *glabella* (G), *nasion* (N), *nasale* (Na), *Point A* (A), *Point B* (B), *suprapogonion* (S Pog), *pogonion* (Pog), *gnathion* (Gn), *menton* (Me). *Facial landmarks: supraglabella* (Sg'), *glabella* (G'), *nasion* (N'), *nasale* (Na'), *subnasale* (Sn), *superior labial sulcus* (SLS), *labrale superius* (LS), *stomion* (Sto), *labrale inferius* (LI), *inferior labial sulcus* (ILS), *suprapogonion* (SPog'), *pogonion* (Pog'), *gnathion* (Gn'), *menton* (Me').

adding a stylized eye. Three of these cases will be presented here to illustrate the method of reconstruction.

Anterior-posterior views were not measured and frontal reconstructions were not attempted in this study since the critical midline soft tissue depths cannot be read from frontal X-rays. Also note that the measurements are enlarged by approximately 10%,[2] that is, a radiographic measurement of 15 mm represents an actual measurement of closer to 13.5 mm (see Ref *27* for compensation tables).

Method

Cephalometric Analysis

From a lateral skull X-ray it is always difficult and sometimes impossible to determine such basic attributes as sex, age, and race. Thus, before beginning a craniographic reconstruction, this information must be supplied by a physical anthropologist or other qualified

[2]A. S. Burns, orthodontist and forensic odontologist, Jacksonville, FL, Personal communication, 1986.

Case Number:
Name:
Sex - Age:
Ethnic Des.:

CRANIOMETRICS		SOFT TISSUE PROJECTIONS	
TFH:	______ mm.	Sg:	______ mm.
UFH:	______ mm.	G:	______ mm.
LFH:	______ mm.	N:	______ mm.
UFH/TFH:	______ %	Na:	______ mm.
SN-Pog:	______	Pt.A-SLS:	______ mm.
SNA:	______	LS:	______ mm.
SNB:	______	Sto:	______ mm.
ANB:	______	LI($\underline{I}$):	______ mm.
AN-Pr:	______	LI($\bar{I}$):	______ mm.
BN-Pog:	______	Pt.B-ILS:	______ mm.
N-Pog-I:	______	SPog:	______ mm.
SKULL TYPE:	____________	Pog:	______ mm.
		Gn:	______ mm.
		Me:	______ mm.

NASO-METRICS

VNL:	_____ mm.
HNL:	_____ mm.
HNL/VNL:	_____ %
X-SN:	_____ mm.
NT^o:	_____

FIG. 2—*Cephalometric data (with soft tissue profile—×10%).*

expert. Ideally, the forensic artist will receive an anthropological report along with the skull films.

While the above traits may be elusive, still much can be learned from a simple skull profile regarding facial proportions and occlusal relations by performing a routine cephalometric analysis. Cephalometric radiography is a sophisticated science, and by applying just a few of its many angulation measurements, the forensic artist can quickly determine the decedent's skull type. The craniometric points and measurements used in this study are illustrated in Fig. 3.

TABLE 1—*Tissue depth data from lateral craniographs (enlargement factor = approximately 10%).*

No.	Measurement	Males (17)	Females (37)
1	Supraglabella	5	4.5
2	Glabella	7	6
3	Nasion	8	7.5
4	Nasale	3.5	3
5	Point A-SLS	17.5	14.5
6	Labrale superior	15	12.5
7	Stomion	7	5.5
8	Labrale inferior ($\bar{I}$)	17.5	14.5
	Labrale inferior ($\underline{I}$)	13	11
9	Point B-ILS	12.5	12
10	Suprapogonion	13.5	12
11	Pogonion	13	11.5
12	Gnathion	10.5	8
13	Menton	10.5	8.5

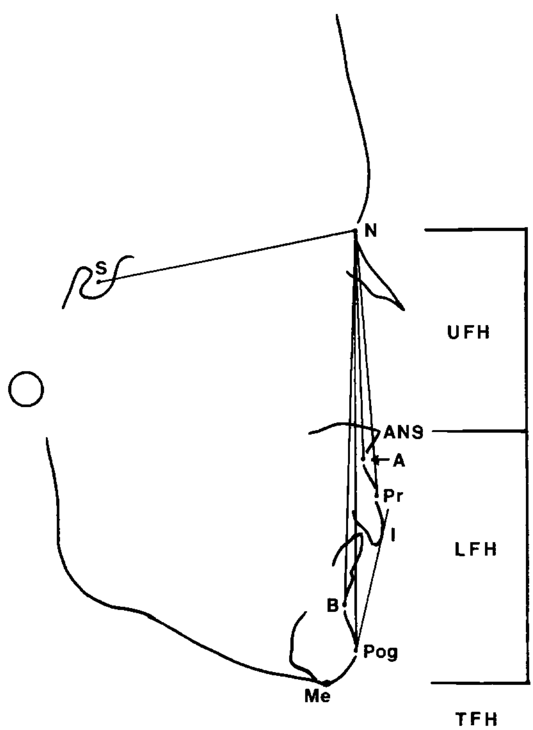

FIG. 3—*Reference points for cephalometric analysis: upper facial height* (UFH), *lower facial height* (LFH), *total facial height* (TFH), *sella* (S), *nasion* (N), *anterior nasal spine* (ANS), *Point A* (A), *prosthion* (Pr), *incisor point* (I), *Point B* (B), *pogonion* (Pog), *menton* (Me).

1. Upper facial height (UFH): the distance from the nasion to the anterior nasal spine. This distance is sometimes designated as the middle facial height in which case the upper facial height is consistent with the forehead. In a well balanced face the UFH is approximately 43% of the TFH [*25*, pp. 4-7].

2. Lower facial height (LFH): the distance from the anterior nasal spine to the menton. In a well balanced face the LFH is approximately 57% of the TFH.

3. Total facial height (TFH): the distance from the nasion to the menton.

4. SN-Pog: this angle (sella-nasion-pogonion) determines the basal position of the mandible and in a balanced face is approximately 80° [*20*, pp. 54-60]. The line N-Pog is referred to as the skeletal facial plane (SFP) and is used as a baseline for many measurements.

5. ANB: this angle defines the relationship of the maxillary and mandibular bases. If Point A lies anterior to NB, the angle is positive, and if posterior to NB, the angle is negative. If NA and NB coincide, the angle is zero. A range of 2 to 5° indicates a normal Class I occlusion. An angle greater than 5° indicates a Class II malocclusion. An angle less than 2° indicates a Class III malocclusion (see Table 2 for a summary of the following measurements).

6. SNA: this angle defines the anteroposterior position of Point A relative to the anterior cranial base and thus the degree of prognathism for the maxilla. Its mean value is 81°.

7. SNB: this angle defines the anteroposterior position of Point B relative to the anterior cranial base and thus the degree of prognathism for the mandible. It has a mean value of 79°.

8. AN-Pr: this angle defines the degree of maxillary alveolar prognathism. The prosthion (Pr) is also called the supradentale (Sd).

9. BN-Pog: this angle defines the degree of mandibular mental prognathism, that is, Point B may be positioned within normal limits yet the chin may be markedly everted.

10. N-Pog-I: this angle defines the relation of the maxillary central incisors to the skeletal facial plane.

Once these angles have been measured the skull type can be encoded by substituting the cranial traits for their angulations in the following formula:

$$\text{ANB} - \text{SNA}/\text{SNB}\ (\text{AN-Pr, BN-Pog})$$

Thus the skull in Fig. 3 may be classified as:

$$\text{I} - \text{O}/\text{O}\ (\text{AP}^{-})$$

TABLE 2—*Cephalometric summary of the relative positions of the maxillary and mandibular bases.*

Angular Measurements	Cranial Traits: Orthognathic	Prognathic	Retrognathic
ANB	2-5° CLASS I	5° CLASS II	2° CLASS III
SNA	78-84°	84°	78°
SNB	77-82°	82°	77°
AN-Pr	0-2°	2°	...
BN-Pog	0-2°	2°	...

where

I = Class I orthognathic occlusion,
O/ = orthognathic maxilla,
/O = orthognathic mandible, and
(AP^-) = slight degree of maxillary alveolar prognathism.

A skull type of II − O/R (AP, MP^+) would be read as follows:

II = Class II prognathic occlusion,
O/ = orthognathic maxilla,
/R = retrognathic mandible,
(AP) = maxillary alveolar prognathism, and
(MP^+) = marked mental prognathism.

And a skull type of III − R/R (MP) would translate as:

III = Class III retrognathic occlusion,
R/ = retrognathic maxilla,
/R = retrognathic mandible, and
(MP) = mental prognathism.

These skull codes not only give indications as to what to expect for a soft tissue profile, but also provide a handy system for filing catalogue study cases. Thus, for example, if you are confronted with a II − P/R (AP) forensic science case, you can pull all similar cases from your study files to serve as potential models.

Nasal Reconstruction

The nose is probably the most distinguishing feature of the face and it is indeed frustrating for reconstructive work that its bony framework is so limited. The definitive features of the nose are thus primarily determined by highly variable cartilages the shapes of which are difficult if not impossible to predict accurately (see Refs *28* and *29* for good descriptions of nasal anatomy). The nose also demonstrates characteristic racial variation [*30–33*] as well as sexual differences [*34*], and continues to grow throughout life (though downward and not outward!, [*35*, pp. 164–172; *36*]).

Despite these apparent difficulties, it is still possible to reconstruct an average nose to fit a given naso-skeletal outline provided the sex, age, and race of the individual are known. In this paper all of the illustrations have been drawn using data for young adult white Americans. Refer to Fig. 4 for a diagram of the method under discussion.

The Nasal Bridge—Begin the reconstruction by plotting the soft tissue points SG′, G′, N′, and Na′ perpendicular to their cranial homologues. The notable exception is N′ which is always lower than N. The angle NSN′ is approximately 4°.

The Nasal Plane—The nasal plane is a horizontal line drawn through the subnasale (Sn), the point where the nose meets the upper lip. This plane is variable, sometimes projecting from the tip of the anterior nasal spine (ANS) and sometimes being as low as Point A [*36*]. In the majority of my study cases, the nasal plane projects from the inferior slope of the ANS halfway between these extremes. The point of intersection is here designated as Point AA.

Vertical Nasal Length—To determine the vertical nasal length, extend the nasal plane until it intersects line NA at Point X. The vertical nasal length thus equals NX and is equivalent to the soft tissue measurement taken by plastic surgeons using a profilometer [*25*, p. 24; *37*].

Horizontal Nasal Length—The horizontal nasal length (XY) can then be calculated as a percentage of the VNL or approximately 60% in males and 55% in females (Table 3). For example, if an unknown male skull has an NX of 62 mm, Point Y can be plotted at 37.5 mm

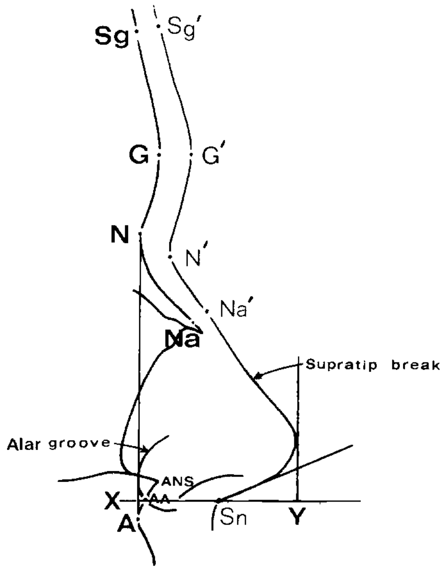

FIG. 4—*Method of nasal reconstruction.* Sg, *cranial supraglabella;* Sg', *facial supraglabella;* G, *cranial glabella;* G', *facial glabella;* N, *cranial nasion;* N', *facial nasion;* Na, *cranial nasale;* Na', *facial nasale;* Sn, *subnasale;* A, *Point A;* ANS, *anterior nasal spine;* NX, *vertical nasal length;* XY, *horizontal nasal length (nasal plane);* AA, *cranial intersection of the nasal plane.*

TABLE 3—*Means and ranges of the HNL/VNL in males and females.*

	Mean, %	Range, %
Males	60.5	55-68
Females	56	46-64

(62 mm $\times$ 0.605 = 37.5 mm). These percentages are also equivalent to the soft tissue measurements taken by plastic surgeons.

The Subnasale—The critical subnasal point can now be precisely plotted on the nasal plane at the mid point of XY. This symmetrically interesting relationship is consistent in both males and females.

The Nasal Tip Angle—This angle is extremely variable and will be discussed in greater detail under common variations. Suffice it here to say that this angle continues to grow downward throughout life, is generally higher in females than in males, and presents diagnostic racial features. In my study sample (mean age of males = 22; mean age of females = 22), the mean nasal tip angle was coincidently 22° in *both* sexes. This angle is easily constructed on the nasal plane (XY) at Point Sn using a simple protractor.

The Nasal Tip—The nasal profile can now be drawn by connecting the soft tissue points from Sg' to Sn. Variations of the nasal tip will be discussed in the common variations section, but a conservative tip can be drawn by rounding the columellar line upward to Line Y where it meets the downward slope of the nasal bridge line. A supratip break is common and represents the overriding of the lateral crus of the alar cartilage over the lateral nasal cartilage.

The Ala—The relationship of the soft tissue ala ("wing of the nose") to the nasal notch of the piriform aperture is frequently misinterpreted. The alar groove is often described as filling the lower rounded border of the notch, but in X-rays the groove can be seen to be anterior and inferior to the notch thus "clipping off" the point of the anterior nasal spine (Fig. 4). This can be explained anatomically by the fact that the nasal notch is mainly filled by a variable number of lesser alar cartilages embedded in fibrofatty tissue [*36,38*] (Fig. 5). It is a well-known fact to rhinoplasticians that the nostril rim and posterior ala are free of these cartilages and that the alar groove "rides over" its cartilagenous supports [*29*]. Accordingly, the alar groove can be positioned as illustrated in Figs. 4 and 5, and the nose completed by adding a conservative nostril line.

Reconstruction of the Lips and Chin

As the nose is to aesthetic surgeons, so the lips are to orthodontists and their literature on the subject is voluminous (see especially Refs *13-17, 21, 24-26*). Great variation exists in the length and thickness of the lips and the best the forensic artist can hope to achieve is an approximation of the most harmonious labial profile that fits a given skull type. Sex and race must also be taken into account and two or three variant profiles may be necessary to cover the known range of variation. Since the mouth is the most expressive feature of the face it may be desirable to show the lips parted or even drawn into a smile, especially if there are peculiarities in the anterior dentition. The soft tissue chin is also highly variable and projections of 17 mm or more are not uncommon [*21,39*]. Refer to Fig. 6 for a diagram of the method of labiomental reconstruction.

Stomion (S)—In the midline, the oral fissure cuts across the lower third (female mean) or quarter (male mean) of the maxillary central incisor. Its thickness (refer to Table 1 for tissue depth data on the following facial points) is influenced by the contact pressure of the lips.

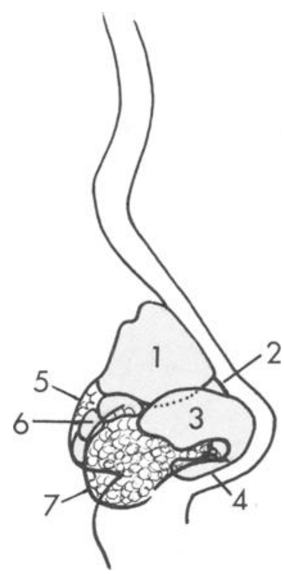

FIG. 5—*Cranial relations of the alar groove:* (1) *lateral nasal cartilage,* (2) *septal cartilage,* (3) *lateral crus of the greater alar cartilage,* (4) *medial crus of the greater alar cartilage,* (5) *nasal notch of the piriform aperture,* (6) *lesser alar cartilages, and* (7) *alar groove.*

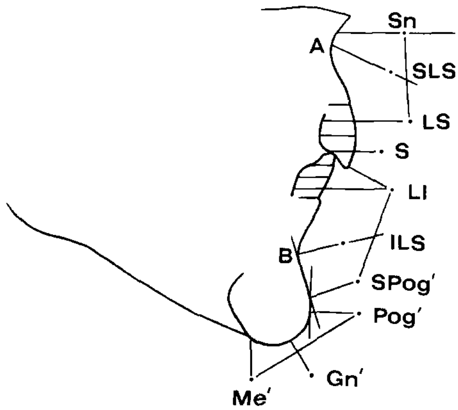

FIG. 6—*Method of labiomental reconstruction.* Sn, *subnasale;* SLS, *superior labial sulcus;* LS, *labrale superius;* S, *stomion;* LI, *labrale inferius;* ILS, *inferior labial sulcus;* SPog, *suprapogonion;* Pog', *pogonion;* Gn', *gnathion;* Me', *menton.*

Labrale Superior (LS)—The highest point on the vermilion border of the upper lip is plotted opposite the upper quarter mark of the maxillary central incisor in both males and females. In blacks, LS is higher reaching the prosthion (supradentale) or even above. In connecting S-LS, the lip line should be slightly angled rather than perfectly curved.

Superior Labial Sulcus (SLS)—The curvature of the upper lip varies with the degree of lip strain and in general is slightly greater in females. The apogee of this arc is almost always lower than its equivalent cranial Point A. To plot SLS, draw a line from Sn to LS. Then extend an oblique line downward from Point A to the Sn-LS midpoint. The average tissue thickness for SLS is then plotted on the oblique line. With deep curvatures the apogee is sometimes above but more often below this point where the lip line frequently makes a slight angle before turning toward LS (Fig. 7*a*). However, the "mid-lip" measurement is necessary to establish a consistent point for average forensic reconstructions.

Labrale Inferior (LI)—This is the most difficult point to assess and will be discussed in more detail in the variations section. In general, the edge of the vermilion border of the lower lip lies opposite the lower three-quarter mark of the mandibular central incisor. Its projection, however, is determined by the maxillary central incisor with which it is in contact, and thus in cases of overbite the measurement from the maxillary incisor is more reliable. There-

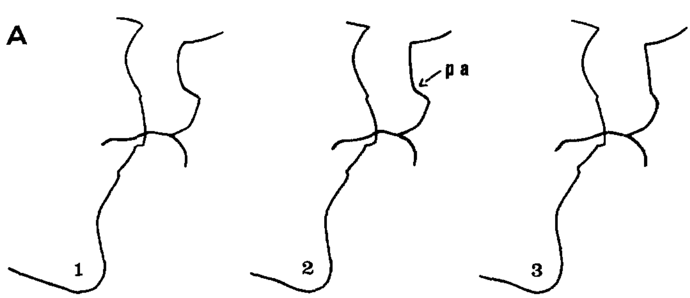

FIG. 7*a*—*Nasolabial contours:* (1) *concave;* (2) *average curve,* pa = *philtral angle;* (3) *straight or convex.*

fore, to plot LI: (1) extend a horizontal line from the three-quarter mark of the mandibular incisor ($\bar{I}$) for the distance listed in the thickness table ($\bar{I}$-LI), and (2) extend a downward line from the tip of the maxillary incisor ($\underline{I}$) to intersect this horizontal line, again according to the thickness table ($\underline{I}$-LI). Two points will thus be plotted on the horizontal line (unless they coincide) and the latter is usually the more accurate.

Suprapogonion (Spog)—In many individuals, especially males, the greatest thickness of the chin is above the standard soft tissue pogonion. To plot SPog, draw a line along the superior slope of the everted mental protuberance and extend a perpendicular from this line for the average thickness.

Inferior Labial Sulcus (ILS)—The apogee of the mentolabial sulcus is usually higher than its equivalent cranial Point B. To plot ILS, draw a line from LI to SPog. Then extend a line from Point B to the LI-Spog midpoint. The average tissue thickness for ILS is then plotted on the Point B line. Note that there is usually a slight angle in the lower lip line just below LI (Fig. 7*b*).

Facial Pogonion (Pog′)—The soft tissue pogonion is plotted on a line drawn perpendicular from the skeletal facial plane (N-Pog) at its tangent to the cranial pogonion.

Facial Menton (Me′)—The soft tissue menton is plotted on a vertical line drawn from the junction of the lower border of the mandible with the posterior border of the mental symphysis. This is a radiological point and differs from the anthropological point which is regarded as the lowest point of the mandible.

Facial Gnathion (Gn′)—This point is variously defined [*20*]. For reconstruction work a point is needed to fill the gap between Pog′ and Me′. Therefore, draw line Pog′-Me′ and mark its midpoint. Then extend a perpendicular line from this midpoint to the mental outline. Gn′ is then plotted on the perpendicular line.

Common Variations

In the preface to her excellent book on drawing the human head [*40*], Louise Gordon writes, "No standard rules are included for those average heads which don't exist. Every head is unique and its position so variable that one can only look at it each time as a new challenge." This undeniable observation is the major source of discomfort to the facial reconstruction artist who is technically limited by the "archetype approach," that is, the determination of the average soft tissue dimensions that fit a given skull. It is axiomatic that any skull can accommodate a wide range of facial forms, yet the graphic method of reconstruction is flexible enough to allow this range of variation to be sampled. Once the average face has been drawn, a limited number of alternatives can be sketched to cover such variables as

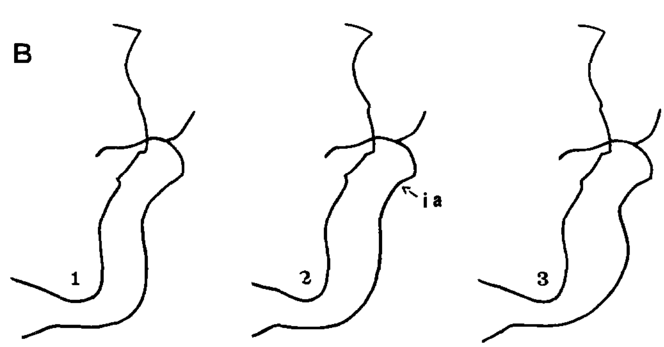

FIG. 7*b*—*Mentolabial contours:* (1) *open;* (2) *average curve,* ia = *infravermilion angle;* (3) *deep.*

nasal angulation and tip shape, lip position, chin form, and even nutritional extremes. These "variations on a theme" thus provide a "postmortem lineup" that should increase the odds for identification.

Nasal Angulation

The normal range for the nasal tip angle is illustrated in Fig. 8. Racial distinctions are clearly evident here from the "hawk-like" proboscides of several Middle Eastern groups to the highly angled and rounded "button noses" of Oriental populations. According to Lewis, the mean nasal angle for adult white males is 12° (range = 5 to 15°) and 18° (range = 10 to 25°) for white females [*34*]. In my study cases of young adult white Americans the mean for both sexes was 22° with a range from 8 to 37°. It should also be observed that the radius of the nasal angle follows an arc as the angle increases [*25*, p. 20].

The nasal tip angle must therefore be arbitrarily set by the artist as it has no obvious cranial determinants. Unfortunately, there are no hard and fast rules for setting this angle. The means recorded above will serve for young adult to middle aged whites, but for older individuals the mean angle is probably lower, and the data on blacks and other ethnic groups are meagre [*31,33*]. Note that increments of 6° do not make an overwhelming difference in the nasal profile (Fig. 8), therefore variant profiles of ±10° or more provide a better range.

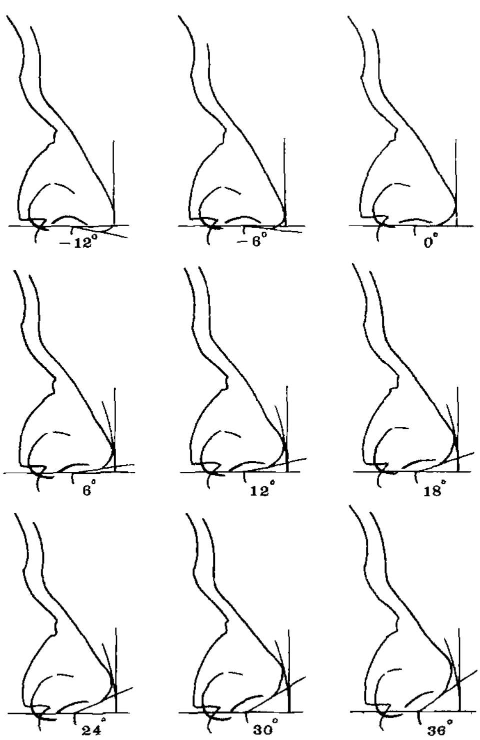

FIG. 8—*Nasal tip angle.*

The Nasal Bridge

Of the three external contours of the nose (bridge, tip, and wing), only the nasal bridge has a bony support. The nasal bones occupy the proximal half of the bridge, the distal half being formed by the lateral and septal cartilages (Fig. 5). The angle and slope of the nasal bones thus provide sturdy clues to the definitive shape of the bridge. The three most common variants (straight, hump, and saddle) are illustrated in Fig. 9. Note that unpredictable elevations and depressions may occur in the lateral and septal cartilages which may significantly alter nasal shape.

The Nasal Tip

The shape of the tip is wholly determined by the greater alar cartilage (Fig. 5) and is therefore unpredictable. Commonly, the tip may be pointed, angled, or rounded (Fig. 9). Excessive development of the lateral crus may exaggerate the supratip break and produce a lateral "hillock" (swelling) above the alar groove. Excessive angling of the medial crus may produce a "hanging columella."

The Ala and Nostril

Positioning of the ala has been previously discussed (Fig. 5). From the side view, the nostril rim may appear to be continuous with the alar groove (closed), or undercut by the groove (open). Posterior or even anterior flaring is also common (Fig. 9). The nostril rim also varies in its curvature altering the exposure of the columella.

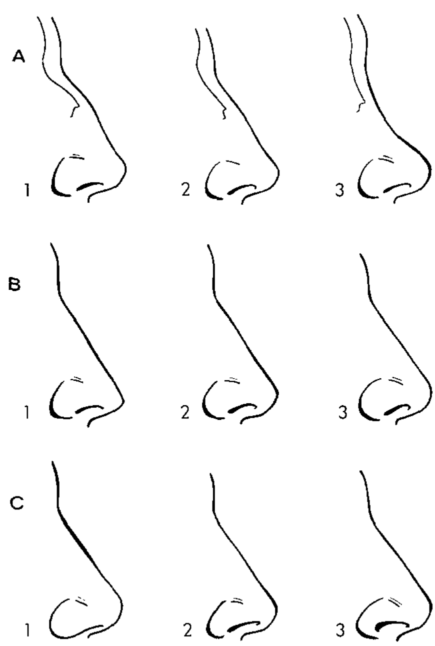

FIG. 9—*Common variations of the nasal profile.* (a) *bridge variants:* (1) *hump,* (2) *straight,* (3) *saddle.* (b) *Tip variants:* (1) *pointed,* (2) *angled,* (3) *rounded.* (c) *Ala-nostril variants:* (1) *closed,* (2) *open,* (3) *flared.*

Even disregarding nasal length, it can be readily computed that the above mentioned common variations can be combined to produce at least 243 nasal types (9 angles × 3 bridges × 3 tips × 3 alar-nostril lines). This is disheartening especially when one considers that these are *common* variations with no mention of such extreme forms as camel humps, turkish saddles, pugs, pigs, Hollywoods, hooks, parrots, parakeets, Pinocchios, and Cyra noses which are the daily fare of rhinoplasticians.

For the reconstruction artist, conservatism is the key. The mean angle combined with a slightly curved bridge, a slightly angled tip, and an open nostril line will give a reasonable approximation of the average nasal profile. Only experience will show which combinations are more natural, for example, low angles are frequently associated with sharp tips and flaring nostrils, and high angles with more rounded tips and closed nostrils. These natural combinations must be kept in mind when developing variant profiles.

The Upper Lip

The relations of the lips and chin to the dental skeleton are of primary concern to orthodontists and maxillofacial surgeons and their extensive literature on the subject clearly indicates that there are no universal laws, just working guidelines. Variations of the nasolabial and mentolabial contours are subtle and bountiful and the reconstruction artist must be aware of the most basic ones.

With reference to the nasolabial contour (Fig. 7*a*), the superior labial sulcus shows the greatest variation resulting in different degrees of upper lip thickness. The SLS reaches its maximum concavity in very thin individuals and is normally deeper in women. In my study cases, both males and females consistently presented a "philtral angle" just above the superior vermilion border.

The Lower Lip and Chin

With reference to the mentolabial contour (Fig. 7*b*), three basic patterns have been defined [*41*] which are primarily determined by the tissue thicknesses at the pogonion-suprapogonion. The open contour is more common in thin individuals and the deep contour is more characteristic of males. The "infravermilion angle" was much less frequent than the corresponding "philtral angle" and was more often present in women.

The Eye

The morphological details of the eye are totally unpredictable from the shape of the orbit and the best the reconstruction artist can strive for is a stylized rendering and an accurate placement. The art books by Gordon [*40*], Hamm [*42*], and Hogarth [*43*] are invaluable for guidelines on drawing the eye, and Stewart's paper [*44*] is essential for its method of proper positioning.

The Ear

The external ear is unique enough to provide individual identifications, but such clues are not forthcoming from the shape of the external auditory meatus. Again, a stylized rendering is the best that can be achieved and the paper by Skiles and Randall [*45*] should be consulted for proper placement.

Aging

It is a fact of life that faces age at different rates and with different intensities. The accurate reconstruction of the post-thirty face requires knowledge and experience together with a good deal of luck. The best artistic study of this general biological process is to be found in Hogarth [*43*], and for a recent scientific study, the reader is referred to Larrabee et al. [*46*].

Study Cases

To illustrate the lateral craniographic method of facial reconstruction, three study cases have been selected which were followed through to completion. Four steps were required: (1) a skull outline with its soft tissue profile was chosen that had been previously traced and measured; (2) the skull outline alone was retraced, the soft tissue profile plotted, and the points connected ("harmonized") as described in the methods section; (3) the *actual* profile and the *reconstructed* profile were then superimposed on a separate sheet to facilitate comparison; and (4) the *outline reconstruction* was finally transferred to a sheet of high quality drawing paper and "humanized" by adding a stylized eye. The completed reconstruction can then be compared with a photograph of the subject.

Study Case One

The subject (Case M-14) is a 25-year-old white American male. The cephalometric analysis (Fig. 10) revealed a Class I^+ occlusion (ANB = 5°) with maxillary prognathism (SNA = 87°), mandibular orthognathism$^+$ (SNB = 82°), and slight mental prognathism (BN-Pog = 2.5°). The upper facial height ratio was also high at 46.8% (mean = 43%) indicating a relatively large nose.

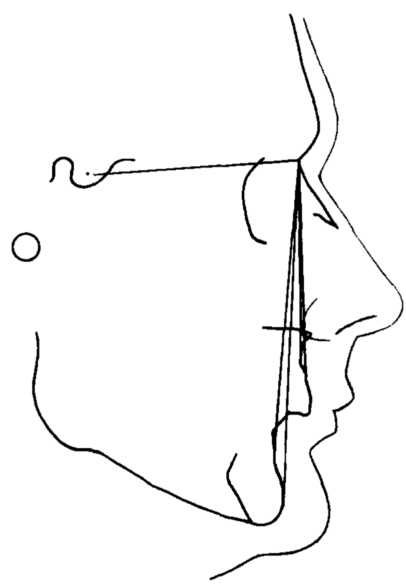

FIG. 10—*Cephalometric analysis. White American male, age 25. Skull type = I^+-P/O^+ (mp$^-$). Actual soft tissue tracing.*

For the reconstruction (Fig. 11), the mean tissue depths were plotted and the nasal angle set at 22°. The tip was slightly angled and rounded, and the nostril line drawn open. Of the two measurements for LI, the distance from *I* (13 mm) was selected because of the marked overbite.

The superimposition (Fig. 12) gives a very close fit. The major discrepancies are in the level of the nasal plane which actually projected from the ANS rather than Point AA (see Ref *36*), and in the chin where the subject had excessive soft tissue development at both Pog (16.5 mm) and Gn (15.5 mm).

The completed profile (Fig. 13) was drawn on Aquabee Satin Finish pencil paper (No. 806) with 2H and HB graphite pencils. All of the illustrations have been reduced by approximately one third from the original X-ray scale.

Study Case Two

The subject (Case F-25) is an 18-year-old white American female. The cephalometric analysis (Fig. 14) revealed a Class II^- occlusion (ANB = 5.5°) with maxillary orthognathism (SNA = 81.5°) and mandibular retrognathism (SNB = 76.5°).

In the reconstruction (Fig. 15) the nasal angle was set at 22°, the tip was slightly angled and rounded, and the nostril line drawn open. The main discrepancies seen in the superimposition (Fig. 16) result from the slight nasal hump which is not indicated by the nasal bones, and the subject's relatively straight upper lip. The final profile is compared with a photograph of the subject in Fig. 17.

Study Case Three

The subject (Case F-37) is a 31-year-old white American female. The cephalometric analysis (Fig. 18) revealed a Class III^+ occlusion (ANB = $-2.5°$) with maxillary and mandibular orthognathism, and alveolar prognathism. For the reconstruction (Fig. 19), as in the pre-

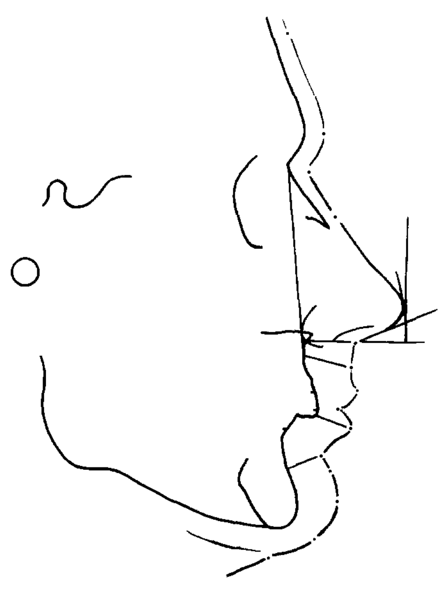

FIG. 11—*Outline reconstruction.*

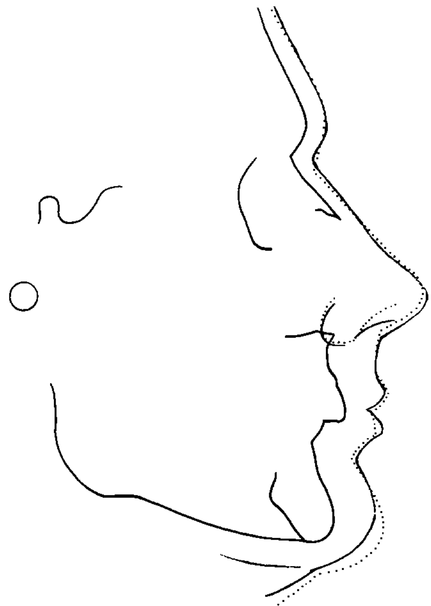

FIG. 12—*Superimposition. Dotted line = actual X-ray tracing. Solid line = outline reconstruction.*

vious two cases, the nasal angle was set at 22°, the tip slightly angled and rounded, and the nostril line drawn open. From the superimposition (Fig. 20), it can be seen that the subject had a relatively low nasal angle (15°) and an intermediate nasal projection (HNL/VNL = 57%). The ILS was higher than usual and the chin was thinner (Pog = 7 mm; Gn = 4 mm; Me = 6 mm). In the completed profile (Fig. 21), the lips are in contact, though in the photograph they are slightly parted.

Discussion

An often heard criticism of forensic facial reconstruction is that given the same skull no two forensic artists will reproduce a similar countenance. The unfortunate truth of this statement points to the lack of scientific standardization required to hold in check variances in artistic skills. The method presented here is an attempt to provide such standardization. Its validity, however, will require further research, much more data, and stringent testing by several forensic artists.

There are advantages and disadvantages to both plastic and graphic methods of reconstruction, but there is no reason why the two methods cannot be integrated to strengthen their weaknesses. For example, a two-dimensional reconstruction could and probably should be developed as a working "blueprint" for more complex sculptures. Clay sculptures are complete, take in many more cranial points, and can be photographed from any angle and under varied lighting conditions. But the clay method *requires the skull* or a cast which often cannot be released, and thus the artist must be "brought to the mountain." And it is tedious and requires considerable artistic skill.

Photographs of the skull can be more easily mailed and graphic reconstructions can then be drawn on tracing paper or frosted acetate directly over the photographs. The views, however, will be limited and calibration of data will be a problem if the photographs are not life-size.

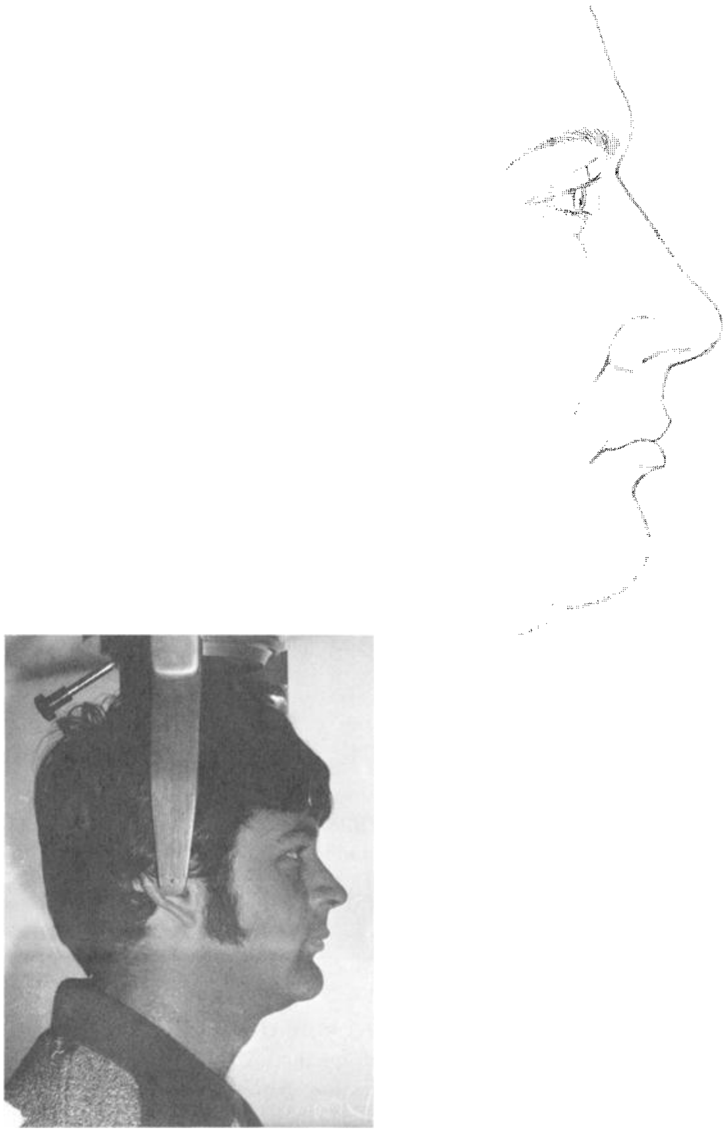

FIG. 13—*Completed reconstruction with photograph of the subject.*

The use of lateral craniographs offers two additional advantages:

1. Calibration is less of a problem since skull films are almost life-size, with an average enlargement factor of approximately 10%. Precise calibrations can be made if the camera-skull and camera-film distances are known [*27*].

2. The skull can be correctly oriented and a cephalometric analysis performed because the critical sella point (S) is visible. The importance of determining the skull type via a single cephalometric analysis cannot be overemphasized. Just as the forensic anthropologist proceeds from general skeletal traits to specific skeletal traits [*47*], the forensic artist must try to individualize a general skull description (sex-age-race). Dentofacial radiography can provide

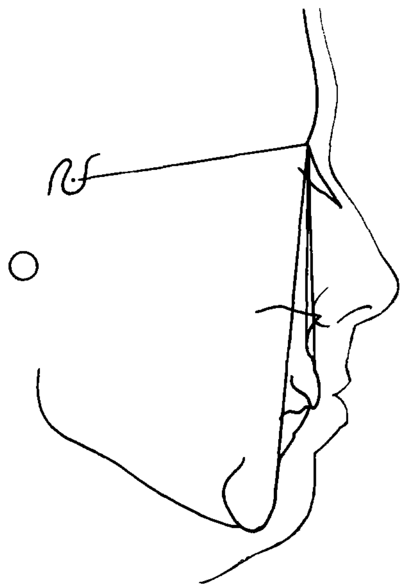

FIG. 14—*Cephalometric analysis. White American female, age 18. Skull type = II^{-}-O/R. Actual soft tissue tracing.*

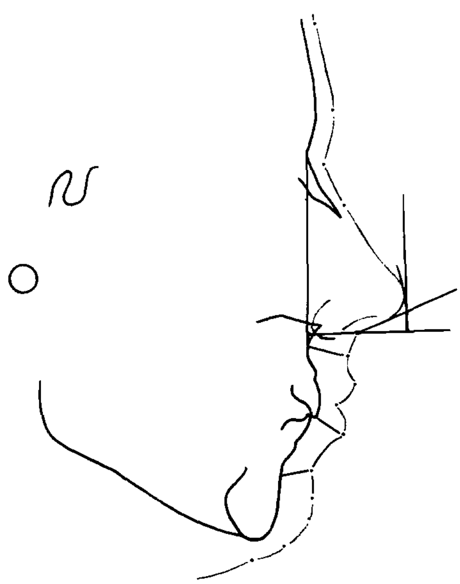

FIG. 15—*Outline reconstruction.*

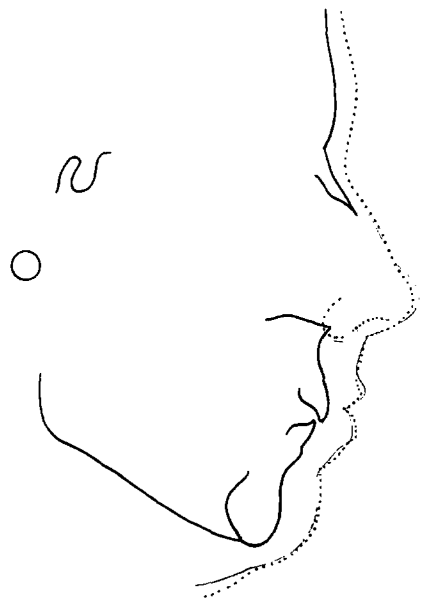

FIG. 16—*Superimposition. Dotted line = actual X-ray tracing. Solid line = outline reconstruction.*

important clues about *general* skull traits [*48*] if a formal anthropological report is not available, but to be able to say that a 40-year-old white male has a skull type = I-P/O (mp) is a major step toward individualization.

Furthermore, the lateral craniographic method provides an effective research tool for collecting data on tissue depths and relations from "living skull" films. High contrast radiographs can be taken which clearly show the soft tissue profile against the skull outline. The important midline anthropometric points, however, cannot be measured from frontal (a-p) views which is why this study has been restricted to lateral craniographs. But frontal reconstructions can still be drawn over anterior-posterior films using published depth data and traditional canons of facial proportion or by the artistic method of "turning a profile" [*43*].

The present study has been limited to a young adult white American population sample. Much more data is needed especially of other ethnic and older age groups. These data must also be sorted with a view toward nutritional extremes [*9*]. Most current research focuses on tissue depth data with less attention being paid to the correlation of cranial and facial landmarks. Peck and Peck were radically insightful when they stated, ". . . the points themselves are meaningless. Ultimate appreciation of the profile depends upon the manner in which these points are connected. Harmonious *profile flow* may be visualized as a series of waves or reversed 'S,s' on the right profile" [*17*]. Lateral craniographs provide an ideal means of analyzing both craniofacial correlates and patterns of profile flow, as well as "living" thickness data. Each study case can then be filed in a general anthropological catalogue (for example, white American females) by skull type for reference in forensic science reconstructions. To date, this method has been applied to five forensic science cases that are currently under investigation.

The application of computer technology to the scientific art of facial reconstruction will undoubtedly be a boon to future research. Computer aided reconstructions have already been applied to both lateral [*49*] and frontal [*50*] views. The main criticism of computerized

FIG. 17—*Completed reconstruction with photograph of the subject.*

reconstructions is that they are heavy on science and light on art. Without some degree of "humanization" a simple outline is no more identifiable than a silhouette. Granted, some silhouettes are identifiable, especially if the individual in question happens to look like Abraham Lincoln, but in most instances some degree of rendering is necessary to capture the subtle nuances of facial expression. In point of fact, compare the outline reconstructions with the completed approximations in Figs. 10 to 21.

With regard to final renderings, the wise forensic artist should keep in mind that every line put down is probably the wrong one. Greatly detailed renderings can, of course, be done but that does not make the final product more accurate, simply more artistic. The result to be aimed for is a realistic, *identifiable* face, drawn with as few lines as possible.

FIG. 18—*Cephalometric analysis. White American female, age 31. Skull type = III^{+}-O/O^{+} (ap). Actual soft tissue tracing.*

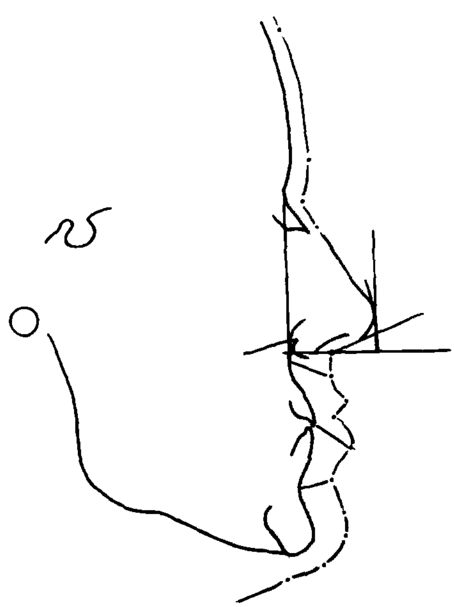

FIG. 19—*Outline reconstruction.*

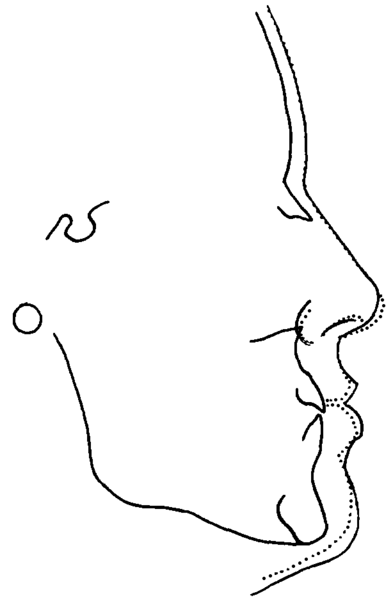

FIG. 20—*Superimposition. Dotted line = actual X-ray tracing. Solid line = outline reconstruction.*

Over the past two years I have been experimenting with a wide variety of portrait styles, drawing papers, graphite and colored pencils, and inks. I am now satisfied with the results obtained using a simple varied line drawn with a 2H or HB pencil on satin finish drawing paper. But these matters will always remain up to the discretion of the individual artist. Another attribute of the craniographic method is that great artistic skill is not required, just the ability to draw a curved line without a ruler.

A further application of graphic methods is that variations can be drawn to cover, for example, the range of nasal angulation, alternate lip postures, nutritional extremes, and facial hair patterns. These variant profiles (paper in preparation) provide a "postmortem lineup" that should increase the odds for identification.

In reference to his famous "proportion man," Leonardo cautioned that "one should use science only as a base for constructing the work of art, and not as an end in itself" (cited in Ref *51*). The modern forensic artist must view the notion that science should not be allowed to obscure the truth of art with skepticism and strive to bring the two a bit closer together.

Acknowledgments

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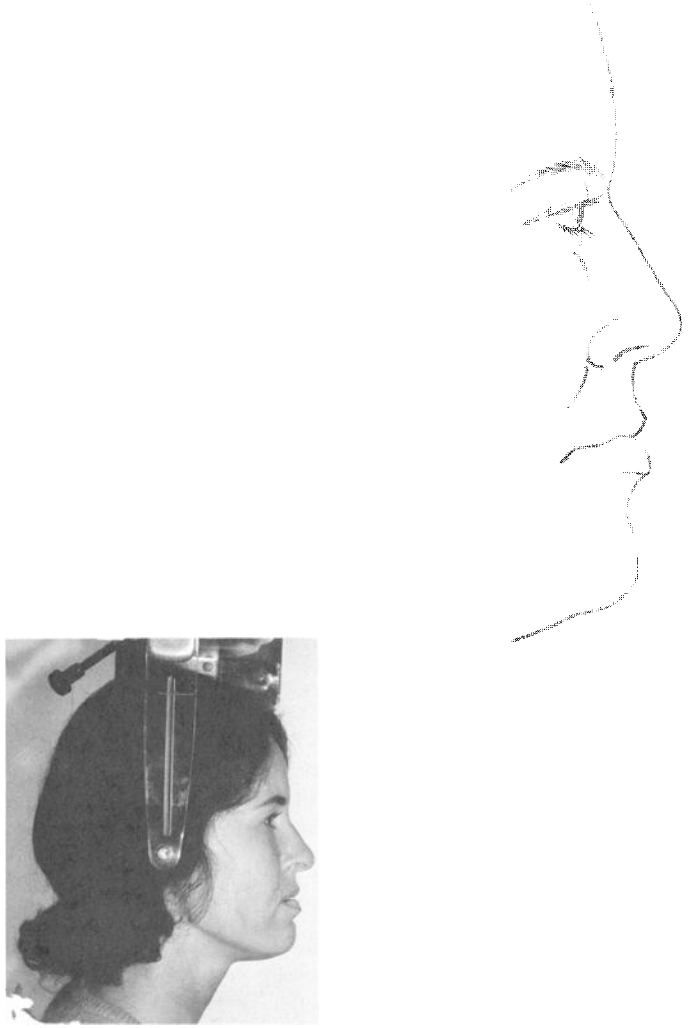

FIG. 21—*Completed reconstruction with photograph of the subject.*

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