Gabrielle Hodson,[1] M.A.; Leslie Sue Lieberman,[2] Ph. D.; and Patti Wright,[3] R.T., R.D.M.S.

In Vivo Measurements of Facial Tissue Thicknesses in American Caucasoid Children

REFERENCE: Hodson, G., Lieberman, L. S., and Wright, P., "***In Vivo* Measurements of Facial Tissue Thicknesses in American Caucasoid Children,**" *Journal of Forensic Sciences*, JFSCA, Vol. 30, No. 4, Oct. 1985, pp. 1100-1112.

ABSTRACT: Ultrasonic determinations were made of facial tissue thicknesses in 50 healthy American caucasoid children, ranging in age from 4 to 15. Twenty measurements were taken at sites along the median, right sagittal, and right lateral planes. A static scanner was used in the B-mode. Three measurements significantly increased with age, the mid-philtrum ($r_s = 0.43$, $p < 0.01$) in females, the mental sulcus ($r_s = 0.30$, $p < 0.05$) in males, and the frontal eminence ($r_s = 0.32$, $p < 0.05$) in both sexes. Moreover, 25% of the measurements, while not statistically significant, decreased with increasing age. These data provide a basis for facial reproductions in caucasoid children.

KEY WORDS: forensic anthropology, human identification, children, facial reproduction, diagnostic ultrasound, *in vivo* measurements, facial tissue thicknesses

Identification of skeletonized remains for forensic science purposes is normally accomplished by a forensic anthropologist. After eliminating nonhuman material, the identification process can produce an expert opinion as to the age, sex, race, stature, anomalies, and sometimes the time since death of the individual in question. Preadolescent skeletal structures rarely exhibit the necessary changes sufficient for identification purposes. When these changes are not evident, and in the absence of dental records, an alternative method has been facial reproduction on the skull [*1-6*]. This method has been used forensically to produce a positive identification in adults [*6*]. However, there are no data available on children's facial tissue thicknesses, which are necessary to produce an accurate facial likeness.

The facial reproduction method presently used in forensic anthropology is based on the skin tissue depth measurements originally collected from cadavera by Welcker in 1883 [7], His in 1895 [*8*], and Kollman and Büchly in 1898 [*9*]. The Kollmann and Büchly tables of skin tissue depths for adults have been successfully used in this country to produce facial reproductions on adult skulls [*10*], but there has been some doubt as to the accuracy of this method [*10,11*]. Gerasimov felt that a better method than skin tissue thicknesses alone was the duplication in clay of the cervical and facial musculature covered by the fatty tissue and skin surface in clay to produce the final visage [*3,4*]. In this country, Krogman has advocated plastic restoration on the skull using the skin tissue tables referred to above [*5,10*]. The

Received for publication 18 May 1984; revised manuscript received 7 Jan. 1985; accepted for publication 18 Jan. 1985.

[1]Graduate student, University of Arizona, Tucson, AZ.
[2]Associate professor, Departments of Anthropology and Pediatrics, University of Florida, Gainesville, FL.
[3]Chief technologist, Division of Diagnostic Ultrasound, Department of Radiology, J. Hillis Miller Health Center, University of Florida, Gainesville, FL.

controversy over the approach to facial reproduction has not been completely resolved, but recently there have been further studies in the measurements of facial tissue thicknesses on present populations [*12,13*].

Rhine has collected data on American blacks [*12*] and recently has published new data on American caucasoid adults [*13*]. In 1948, Suzuki published a similar table for Japanese facial tissue thicknesses [*14*]. These measurements were taken using essentially the same technique originally employed by Kollmann and Büchly in 1898. The technique involves the insertion of a rubber-collared needle into soft tissue until bone is encountered at various standard anthropometric sites on the face [*10-12,14*]. All previous measurements were taken from cadavera populations [*7-9,12,14*].

An alternative method is the application of diagnostic ultrasound for the measurement of skin and subcutaneous tissue thicknesses *in vivo*. Ultrasound was initially used by industry to detect flaws in metals and other materials [*15*]. The first biological application of ultrasound was the determination of subcutaneous fat components in livestock[4] [*15*]. In past years, there have been many studies regarding the potential use of ultrasonics in body composition research[4] [*16-23*], and for some sites it is a method of measurement potentially superior to calipers in humans [*24,25*]. In addition, Stouffer refers to a study in which direct comparison was made between X-ray, ultrasound, ruler probe, and lean meter measurements, in which ultrasound was found to be comparable to X-rays in accuracy [*22*]. The ruler probe and lean meter measurements, which are similar to the rubber-collared needle technique used in forensic anthropological research, were not as accurate as ultrasound and X-ray [*22*]. The purposes of this study are: (1) to present a table of average facial tissue thicknesses for American caucasoid children; (2) to determine the relationship between facial tissue thicknesses and sex in children; and (3) to determine the relationship between facial tissue thicknesses and age in children.

Method and Materials

Sample

The present study population was a sample of healthy American caucasoid children of Northern European descent. Children with an obvious weight problem or medical disorder were not included. The subjects were 22 females and 28 males and ranged from 4 to 15 years of age. No children under the age of four were included because of a lack of sufficient bony facial maturity and the lack of cooperation in younger children. All the children voluntarily participated in this study. Ninety-four percent of the subjects in this study were cooperative and excited to contribute to the problem of missing children. The three hesitant children were all four years of age, and had recently experienced adverse medical experiences. Because a child must hold still for 2 min and have a small amount of nonallergenic water soluble ultrasonic gel placed on the face, the presence of a parent and a trusting relationship between child and ultrasound technician is preferable. During the ultrasonic procedures in this study, the children's reactions were generally favorable.

Ultrasound Technology

This study used diagnostic ultrasound, which is electrical energy converted by piezoelectric crystals into sound waves (in frequencies beyond human audibility limits). The resulting echoes received are converted into distance (time) and recorded as a two-dimensional picture on an oscilloscope [*26*]. The Technicare EDP 1000 "Sonograf" static scanner (manufactured by Johnson & Johnson) was used in the B-mode. B-mode ultrasonography (wavelengths of 0.3 to 1.5 mm) refers to the method of scanning which is commonly used for any part of the

[4]L. Lussier, "The Use of Ultrasound in Body Composition Research," Manuscript, Noll Laboratory of Human Performance Research, Pennsylvania State University, University Park, PA, 1974.

human body except the heart in a medical application. B-mode is based on the pulse-echo principle [*26*]. Standard diagnostic scanning equipment generate 1000 pulses per second. These pulses travel through the tissue until a different tissue density (acoustical interface) is encountered, at which time a portion of the pulse is reflected back (echo) and recorded in distance as a picture on the oscilloscope (see Fig. 1).

A short-focus transducer made of lead titanate zirconate (a synthetic crystal) was used in the 7.5-MHz frequency range with a 0.6-mm wavelength. The short focus offers better resolution at closer ranges (two surfaces close together will appear as separate echoes). The greatest thickness of facial tissue in children is estimated to be 25 mm; therefore the 7.5-MHz transducer was used, which has a penetration capacity of 1 to 80 mm in depth. Frequency is defined as "how many times the crystal expands and contracts per second" [*26*]. The synthetic crystal within the transducer generates mechanical vibration energy, sending a narrow beam of sound pulses into the tissues. The higher the frequency, the better the resolution of the picture. Resolution in ultrasonography refers to the ability of the equipment of record echoes between 0.3 and 1.5 mm in distance separately on the oscilloscope [*26*]. A 10.0-MHz transducer is recommended for the best resolution, but was not available at the

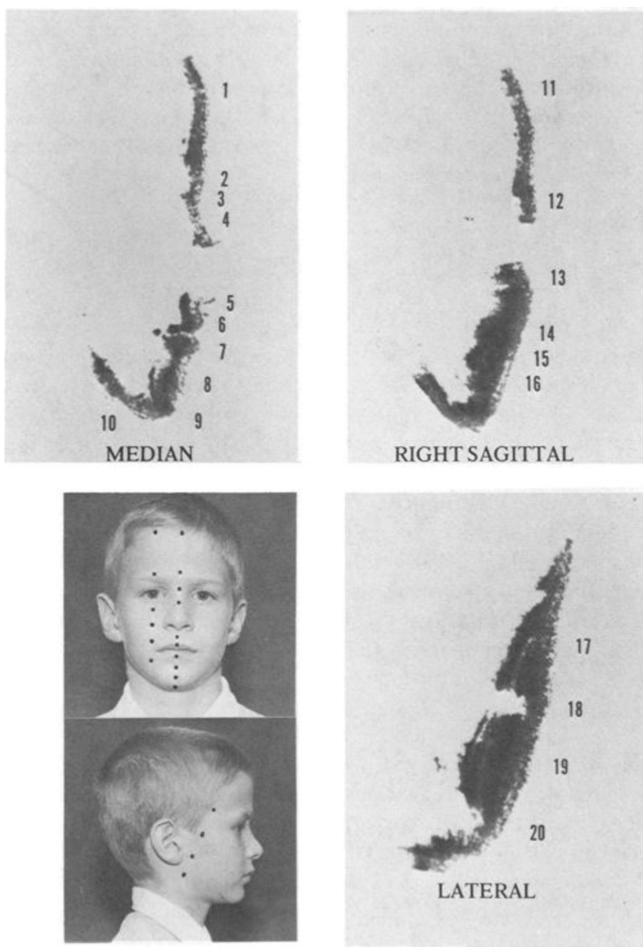

FIG. 1—*Ultrasonographic films with measurement sites indicated on films and child's face.*

time of this study. The 7.5-MHz transducer was internally focused (the face of the transducer is flat), allowing good skin-transducer contract to be maintained and decreasing problems associated with poor skin contact, such as attenuation.

When ultrasound travels through human tissue the pulse is undergoing continuous change [*26*], the most significant of which is attenuation. Attenuation is the progressive weakening of the pulse as it travels through the various tissue interfaces (fat, muscle, bone). The processes through which attenuation occurs are absorption, reflection, and scattering [*26*]. Absorption occurs when the mechanical energy of the sound is converted into heat. Reflection is the redirection of the pulse back to its source, and scattering "occurs when the beam encounters an interface which is irregular and smaller than the sound beam" [*26*]. An interface occurs between two tissues of different acoustic impedance. Scattering and reflection were the two artifacts most commonly encountered in this study, particularly in the areas over the nasal bones and the mouth. Absorption is associated with "diathermy," a treatment commonly used in physiotherapy, employing a different mode of ultrasonography, and was therefore not encountered in this application of diagnostic ultrasound. Because of the problems with reflections, the face must be scanned with a relatively short depth of penetration at a low sensitivity or gain level, thus reducing the number of echoes received.

Ultrasound is a noninvasive low risk method widely used in medical applications. The risks in ultrasound are thermal effects, cavitation, and direct mechanisms [*27*]. A temperature rise (thermal effects) in the tissues is generally referred to as "diathermy." This effect requires intensity levels greater than 100 times those used in diagnostic ultrasound. Cavitation refers to "regions of ... stress ... in liquid sufficient to break subcellular structures" [*27*]. Intensity levels required to produce this effect must be more than 2000 times greater than those used in medical applications [*27*]. Direct mechanisms, or mechanical effects on tissue, have been the subject of extensive research for many years. The possible ultrasonic acceleration of chemical reactions or chromosome damage has been of some concern. However, a committee of the American Institute of Ultrasound in Medicine has issued the following statement regarding possible mammalian *in vivo* ultrasonic effects: "In the low megahertz frequency range there have been (as of this date) no demonstrated significant biological effects in mammalian tissues exposed to intensities below 100 mW/cm^2" [*28*]. Most diagnostic machines operate in the 15 milliwatts per square centimetre (mW/cm^2) range [*27*]. "An ultrasonic intensity of 100 mW/cm^2 or less was of little or no hazard for at least 10 000 seconds" [*27*]. The scanner used in this study operates at a time-averaged intensity level of 5 to 10 mW/cm^2, and the average time of exposure to ultrasound was 100 to 120 seconds (s).

Measurement Sites

Twenty measurements were made along the median, right sagittal, and right lateral planes. The measurement sites were: (1) supraglabella, (2) glabella, (3) nasion, (4) end of nasals, (5) mid-philtrum, (6) upper lip margin, (7) lower lip margin, (8) mental sulcus, (9) mental prominence, (10) beneath chin, (11) frontal eminence, (12) mid-eyebrow, (13) suborbital, (14) inferior malar, (15) supra M^2, (16) sub M_2, (17) mid-temporal, (18) mid-zygomatic arch, (19) occlusal line, and (20) gonion (see Fig. 2). The sites chosen were taken from the traditional Kollmann and Büchly points [*9*] and the sites measured by Rhine [*13*]. Figure 1 indicates these measurement sites on ultrasonographic film with corresponding points on the photograph of the child's face.

Techniques

Each child was asked to lie flat on his or her back on an examining table with a rolled towel under the neck to maintain facial position. Towels were placed on each side of the face to reduce movement. The child was asked to close eyes and mouth with teeth together (edge

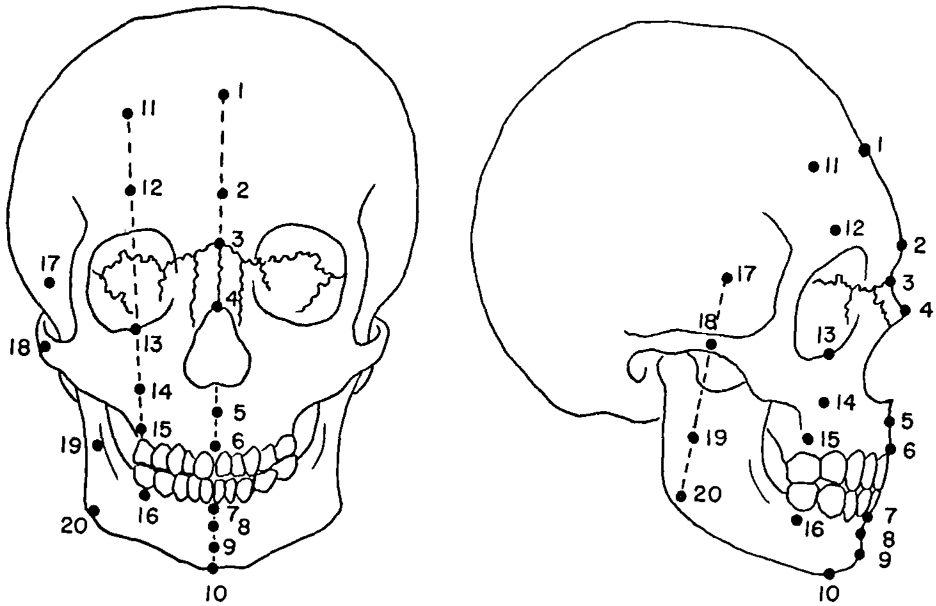

FIG. 2—*Frontal and right lateral views of human skull with measurement sites indicated.*

to edge), and relax facial features as if in sleep. The closure of the teeth tended to reduce the possibility of scattering and reflection on the resulting ultrasonographic film. A small amount of nonallergenic water soluble ultrasonic gel was placed on the plane of the face being scanned and on the tip of the transducer to enhance contact. Before scanning, the child's vital information (sex, age, race, the date) was entered on the screen (see Fig. 3). The gel was wiped off the face after each plane was scanned. The ultrasonic films were developed

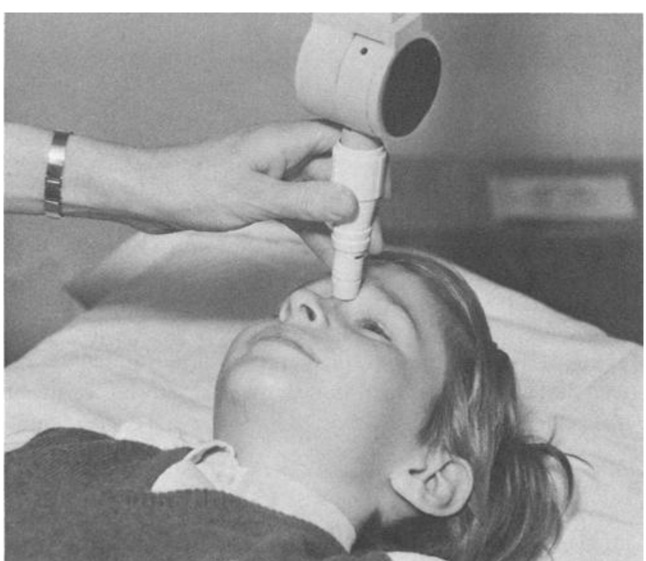

FIG. 3—*Ultrasonography (B-mode) in progress on the median plane of child's face. (Photography by Ray R. Hale, II).*

in the usual roentgenographic manner, producing four "plane" views on each film plate which also included the child's vital information as described above.

Analysis of the ultrasonographic films were carried out on a light box using a "Royal Mecanic Precision Caliper in Nylon-Asbestes" (Swiss-made). This caliper is accurate to within 0.01 mm. Ultrasonographic films produce an image which is one-half actual life size. Therefore, the measurements were multiplied by a constant (2.0) for conversion to actual size. The measurement process was further facilitated by ultrasonographically marking the films with calibrated dotted lines at each measurement site during the scanning process. The transducer tip was placed lightly on each measurement site and a calibration mechanism was activated, producing a line of dots (2 cm between each dot in actual life size) beginning at the tip of the transducer (skin surface) and radiating in a straight line parallel to the angle of the transducer and perpendicular to the surface of the skin. This line of dots on the ultrasonographic films prevented any subjective miscalculation of the skin surface and depth measurement in conversion to actual size. These film markings also insured correct assessment of placement of the measurement site on the films and eliminated any possibility of measurement miscalculations caused by transducer surface depression during ultrasound.

Five children were measured by two different operators on the same day to assess interoperator error, and five were measured twice at different times (range 2.5 to 5.0 weeks) to assess intraoperator error.

Results

Results of the data are presented in Tables 1, 2, 3, and 4. Means, ranges, standard deviations, and coefficients of variations, for male and female children ($n = 50$), are presented in Table 1. The measurements are presented in millimetres. Table 2 reports the differences between measurements that can be attributed to sex. The only measurement with a statistically significant difference was the mid-philtrum ($t = 2.14$, DF = 48, $p < 0.05$). The male mean was 10.8 mm, with a range of 8.6 to 13.6 mm (SD = 1.10). The female mean was

TABLE 1—*Means and ranges of facial tissue thicknesses*[a] *in American caucasoid children.*

Measurement Site	Mean	Male and Female Range	($n = 50$) SD	C.V., %
(1) Supraglabella	5.7	4.6-6.7	0.54	9.5
(2) Glabella	5.3	4.0-8.1	0.77	14.5
(3) Nasion	5.3	3.5-6.8	0.88	16.6
(4) End of nasals	2.2	1.3-3.8	0.66	30.0
(5) Mid-philtrum	10.5	7.3-13.6	1.34	12.8
(6) Upper lip margin	9.7	7.4-12.2	1.28	13.2
(7) Lower lip margin	10.6	8.2-13.3	1.13	10.7
(8) Mental sulcus	8.2	5.8-10.6	1.07	13.0
(9) Mental eminence	6.8	4.6-9.2	1.13	16.6
(10) Beneath chin	4.2	2.3-6.1	0.80	19.0
(11) Frontal eminence	5.8	4.5-7.5	0.69	11.9
(12) Mid-eyebrow	6.4	4.5-9.3	1.08	16.9
(13) Suborbital	6.5	4.8-9.3	0.95	14.6
(14) Inferior malar	17.3	12.0-21.4	1.97	11.4
(15) Supra M^2	12.3	8.8-14.9	1.42	11.5
(16) Sub M_2	10.4	7.1-14.0	1.52	14.6
(17) Mid-temporal	9.0	5.9-11.4	1.23	13.7
(18) Mid-zygomatic arch	7.3	5.5-9.3	0.92	12.6
(19) Occlusal line	18.1	12.0-22.1	2.03	11.2
(20) Gonion	7.8	4.8-11.1	1.42	18.2

[a] Measurements in millimetres.

TABLE 2—*Results of* t-*test for sexual differences between children's facial tissue thicknesses.*[a]

Measurement Site	Male $n = 28$ Mean	Male Range	Male SD	Female $n = 22$ Mean	Female Range	Female SD	t	DF	p
(1) Supraglabella	5.7	4.6-6.7	0.59	5.5	4.7-6.6	0.46	1.33	48	0.19
(2) Glabella	5.4	4.0-8.1	0.83	5.3	4.3-6.8	0.70	0.59	48	0.57
(3) Nasion	5.3	3.6-6.6	0.81	5.3	3.5-6.8	0.95	0.26	48	0.79
(4) End of nasals	2.2	1.3-3.6	0.72	2.2	1.5-3.8	0.59	0.26	48	0.79
(5) Mid-philtrum[b]	10.8	8.6-13.6	1.10	10.0	7.3-12.5	1.51	2.14	48	0.03
(6) Upper lip margin	9.7	7.4-11.6	1.26	9.8	7.5-12.2	1.32	0.10	48	0.92
(7) Lower lip margin	10.8	8.3-13.3	1.15	10.4	8.2-12.8	1.09	1.21	48	0.23
(8) Mental sulcus	8.5	6.4-10.6	1.11	7.9	5.8-9.8	0.97	1.77	48	0.08
(9) Mental eminence	6.9	4.6-9.2	1.18	6.6	4.6-8.6	1.07	0.89	48	0.62
(10) Beneath chin	4.3	2.3-6.1	0.86	4.1	2.5-5.1	0.71	0.79	48	0.56
(11) Frontal eminence	5.9	4.5-7.5	0.67	5.6	4.5-7.0	0.69	1.67	48	0.10
(12) Mid-eyebrow	6.4	4.5-9.3	1.28	6.4	5.2-8.0	0.80	0.06	48	0.95
(13) Suborbital	6.5	5.2-8.4	0.94	6.6	4.8-9.3	0.99	0.41	48	0.69
(14) Inferior malar	17.5	14.0-21.4	2.14	17.1	12.0-20.0	1.76	0.72	48	0.52
(15) Supra M^2	12.4	8.8-14.9	1.60	12.3	10.2-14.5	1.20	0.11	48	0.91
(16) Sub M_2	10.7	7.4-14.0	1.69	10.2	7.1-12.4	1.27	1.09	48	0.28
(17) Mid-temporal	9.3	6.6-11.4	1.15	8.7	5.9-11.0	1.27	1.84	48	0.07
(18) Mid-zygomatic arch	7.4	5.8-9.2	0.90	7.2	5.5-9.3	0.96	0.88	48	0.62
(19) Occlusal line	18.4	15.6-21.6	1.78	17.8	12.0-22.1	2.30	1.08	48	0.29
(20) Gonion	7.4	4.8-10.8	1.42	7.9	5.4-11.1	1.45	0.54	48	0.60

[a] Measurements in millimetres.
[b] Significant thickening $p < 0.05$.

TABLE 3—*Spearman's ranked correlation coefficients by age (*n = *50).*

Measurement Site	Correlation Coefficients
(1) Supraglabella	0.18
(2) Glabella	0.15
(3) Nasion	0.12
(4) End of nasals	0.12
(5) Mid-philtrum[a]	0.43
(6) Upper lip margin	0.14
(7) Lower lip margin	0.02
(8) Mental sulcus[b]	0.30
(9) Mental eminence	0.17
(10) Beneath chin	0.19
(11) Frontal eminence[b]	0.32
(12) Mid-eyebrow	0.24
(13) Suborbital	—0.10
(14) Inferior malar	—0.06
(15) Supra M^2	—0.02
(16) Sub M_2	0.05
(17) Mid-temporal	—0.001
(18) Mid-zygomatic arch	0.09
(19) Occlusal line	0.05
(20) Gonion	—0.07

[a] $p < 0.01$.
[b] $p < 0.05$.

10.0 mm, with a range of 7.3 to 12.5 mm (SD = 1.51). All other sites showed no significant differences by sex.

To assess the possible changes in facial tissue thicknesses as children mature a Spearman's ranked correlation coefficient test was performed. The analysis of the data is presented in Table 3. The mid-philtrum ($r_s = 0.43$, $p < 0.01$), the mental sulcus ($r_s = 0.30$, $p < 0.05$), and the frontal eminence ($r_s = 0.32$, $p < 0.05$) all showed statistically significant thickening with age for male and female children. Although some sites did not exhibit statistically significant changes, they did show some decrease in thickness with age. These sites were the suborbital, the inferior malar, the supra M^2, the mid-temporal, and the gonion.

The data analyzed above for age were then separated by sex and analyzed again. The data were computed for children under twelve and over twelve years of age to determine the correlation of sex and age. The results are reported in Table 4. There was a significant thickening in the mid-philtrum for the older female group ($t = 2.3$, DF = 20, $p < 0.03$), and a significant thickening in the mental sulcus for the older male group ($t = 2.9$, DF = 26, $p < 0.01$), while the frontal eminence showed no statistical difference (see Fig. 4). Apparently, the frontal eminence thickens with age in both male and female children.

The interoperator assessment of error revealed no significant differences in measurements, except at Site 10 (beneath chin), between the first and second measurements ($t = 2.65$, DF = 6, $p < 0.05$). The first measurement showed a mean of 3.7 mm and the second measurement showed a mean of 4.6 mm. This error may be explained by the difficulty in maintaining skin-transducer contact whle scanning over the chin. The transducer must change in relationship to the hand from approximately 90° to approximately 30° in a distance of about 1 cm. This maneuver was improved as the study progressed; therefore, the earlier measurements are not as consistently accurate as later measurements taken at this site.

TABLE 4—*Results of* t*-test for age differences within each sex.*[a]

	Male					Female				
Measurement Site	Younger $n = 19$ Mean	Older $n = 9$ Mean	t	DF	p	Younger $n = 15$ Mean	Older $n = 7$ Mean	t	DF	p
(5) Mid-philtrum	10.5 ± 0.92	11.4 ± 1.29	2.0	26	0.1	9.6 ± 1.4	11.0 ± 1.3	2.3	20	0.03
(8) Mental sulcus	8.1 ± 0.96	9.2 ± 1.04	2.9	26	0.01	7.7 ± 1.03	8.5 ± 0.6	1.8	21	0.1
(11) Frontal eminence	5.8 ± 0.7	6.1 ± 0.6	1.1	26	0.3	5.5 ± 0.7	5.8 ± 0.7	0.7	20	0.5

[a]Differences for the three measurement sites which showed significant increase with age, in order to ascertain the relationship to sex for these sites only.

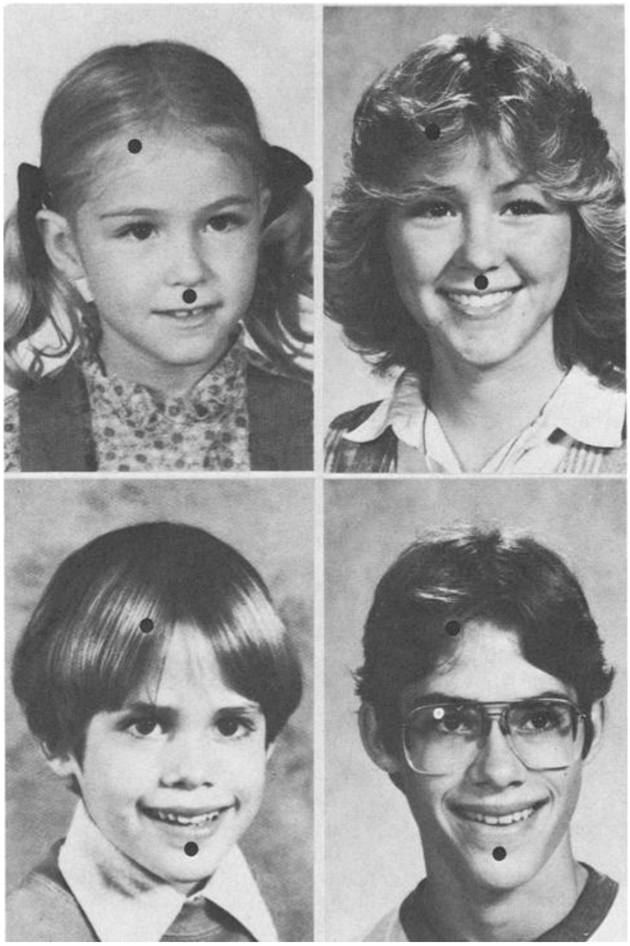

FIG. 4—*Measurement sites significantly increased with age in male and female children.*

Discussion and Conclusions

In 1982 an estimated 100 000 children were reported missing in the United States [*29*]. Approximately an estimated 2500 were later found murdered [*29*]. This number does not include those unidentified by the usual medical or anthropological methods. There is a growing urgency to develop new methods of identification for deceased children in this country.

The data presented make possible for the first time facial reproductions of unknown children's remains. Ultrasonic determinations of *in vivo* measurements further increases the accuracy of the data reported.

The differences reported between male and female children, as well as the statistical differences reported within the sexes for younger and older children, may be the result of the dynamics of growth. Krogman found that females "tend to have a slightly greater absolute gain [in facial growth] ... especially in mid-face depths" [*30*]. This growth precocity exhibited in females during puberty may account for the significance in the measurement differences reported for the mid-philtrum. This study measured only children between the ages of four and fifteen, hence the data needed for further comparison in pubertal growth spurts, especially in males, is not verifiable. Further research on older adolescent children is necessary to ascertain the possible relationship of facial tissue thickness and age in the pre-adult years. Again, this process of "moments" in facial growth is the result of acceleration and then slowing down of facial growth in relationship to time [*30*]. Comparison between adult and children's facial tissue thickness measurements may prove useful in determining the most accurate measurement to use in a particular facial reproductive case.

The possible statistically significant changes in facial tissues at death have yet to be investigated. However, the marked differences in the outward appearance of the face within minutes of death have been substantiated and reported in the literature [*31*]. The difficulties encountered in the measurement of facial tissues after death are considerable [*11*]. Whether these surface differences are statistically significant for the underlying tissue thickness measurement in humans has not been tested. The future of facial reproduction in this country as a viable method of human identification will largely be determined by the ability to obtain accurate facial tissue thicknesses data and the ability to assess accurately the effect of bony anatomical variations upon the surface physiognomy of the individual. The data currently available in the literature have all been collected from cadavera populations [*8-14*]. A comparison of the present data with *in vivo* measurements on adults may prove useful in an accurate compilation of facial tissue thicknesses. *In vivo* measurements are currently being collected for an adult American caucasoid population and comparable data will be published.

The ultrasonic determination of facial tissue thicknesses requires extensive training in the use of ultrasound equipment and an accurate interpretation of the films. It is suggested that the researcher either obtain this training before attempting diagnostic ultrasonic research, or use the services of an experienced ultrasound technologist. A radiologist with expertise in ultrasonics may prove useful in ultrasonographic film interpretation. Despite these requirements, diagnostic ultrasound is a potentially superior method for obtaining facial tissue thicknesses in all age groups.

Summary

The first *in vivo* measurements of facial tissue thicknesses for caucasoid children are presented. Diagnostic ultrasound was used in the B-mode to produce an accurate measurement at 20 standard anthropometric sites in 50 healthy American caucasoid children. Three measurements significantly increased with age and five measurements, while not statistically significant, decreased with age. Diagnostic ultrasound is a potentially superior facial tissue thickness measurement technique, but ultrasonics requires proficiency in scanning techniques and film interpretation. The data reported provide a basis for facial reproductions on unknown children's skeletal remains. Children's remains without dental records or skeletal changes present a unique identification problem to the forensic anthropologist. The facial tissue thickness data presented can significantly contribute to a solution for the growing dilemma of missing children.

Acknowledgments

Our research was made possible through the cooperation of Juri V. Kaude, M.D., professor and chief, Division of Diagnostic Ultrasound, Department of Radiology, J. Hillis Miller Health Center, University of Florida; Roger Shaver, M.D., radiologist, Fort Myers, FL; and Linda D. Wolfe, Ph.D., assistant professor, Department of Anthropology, University of Florida. I am indebted to the children and parents of the Church of Jesus Christ of Latter Day Saints and the Flowers Montessori School of Gainesville, FL, for their willing participation.

References

[1] Caldwell, M. C., "The Relationship of the Details of the Human Face to the Skull and its Application in Forensic Anthropology," M.A. thesis, Department of Anthropology, Arizona State University, Tempe, AZ, May 1981.

[2] Gatliff, B. P. and Snow, C. C., "From Skull to Visage," *Journal of Biocommunications*, Vol. 6, No. 2, 1979, pp. 27-30.

[3] Gerasimov, M. M., *Osnovy Vosstanovlieniia Litsa po Cherapu*, Gos. Izd-vo Sovetskaia Nauka, Moskva, 1949.

[4] Gerasimov, M. M., *The Face Finder*, Lippincott, New York, 1971.

[5] Krogman, W. M., "The Reconstruction of the Living Head from the Skull," *FBI Law Enforcement Bulletin*, Vol. 15, No. 7, July 1946, pp. 11-18.

[6] Snow, C. C., Gatliff, B. P., and McWilliams, K. R., "Reconstruction of Facial Features from the Skull: An Evaluation of Its Usefulness in Forensic Anthropology," *American Journal of Physical Anthropology*, Vol. 33, No. 2, Sept. 1970, pp. 221-227.

[7] Welcker, H., *Schiller's Schadel und Todenmaske, nebst Mittheilungen uber Schadel und Todenmaske Kants*, Fr. Vieweg und Sohn, Braunschweig, 1883, pp. 1-160.

[8] His, W., "Anatomische Forschungen ueber Johann Sebastian Bach's Gebeine und Antlitz' nebst Bemerkungen ueber Dessen Bilder," *Abhandlungen der Mathematisch-Physikalischen Klasse der Konigl. Sachsischen Gesellschaft der Wissenschaften*, Vol. 22, 1885, pp. 379-420.

[9] Kollmann, J. and Büchly, W., "Die Persistenz der Rassen und die Reconstruction der Physiognomie Prahistorischer Schadel," *Archiv fur Anthropologie*, Vol. 25, 1898, pp. 329-359.

[10] Krogman, W. M., *The Human Skeleton in Forensic Medicine*, Charles C Thomas, Springfield, IL, 1962.

[11] Stewart, T. D., *Essentials of Forensic Anthropology*, Charles C Thomas, Springfield, IL, 1979.

[12] Rhine, J. S. and Campbell, H., "Thickness of Facial Tissues in American Blacks," *Journal of Forensic Sciences*, Vol. 25, No. 4, Oct. 1980, pp. 847-858.

[13] Rhine, J. S. and Moore, C. E., "Facial Reproduction Tables of Facial Tissue Thicknesses of American Caucasoids in Forensic Anthropology," *Maxwell Museum Technical Series #1*, Albuquerque, NM, 1982.

[14] Suzuki, K., "On the Thickness of the Soft Tissue Parts of the Japanese Face," *Journal of the Anthropological Society of Nippon*, Vol. 60, 1948, pp. 7-11.

[15] Whittingham, P. D. G. V., "Measurement of Tissue Thickness by Ultrasound," *Aerospace Medicine*, Vol. 33, Sept. 1962, pp. 1121-1128.

[16] Bullen, B. A., Quaade, F., Olesen, E., and Lund, S. A., "Ultrasonic Reflections Used for Measuring Subcutaneous Fat in Humans," *Human Biology*, Vol. 37, No. 4, Dec. 1965, pp. 375-384.

[17] Lieberman, L. S., "Growth and Development, Nutrition and Activity Among Diabetic Youngsters," *Florida Scientist*, Vol. 43, 1980, pp. 141-147.

[18] Lieberman, L. S., Rosenbloom, A. L., Riley, W. J., and Silverstein, J. A., "Reduced Skin Thickness with Pump Administration of Insulin," *New England Journal of Medicine*, Vol. 303, 16 Oct. 1980, pp. 940-941.

[19] Lieberman, L. S., "Ultrasonic Measurement of Body Composition in Children with Diabetes Mellitus," *American Journal of Physical Anthropology*, Vol. 50, No. 3, March 1979, pp. 458-459.

[20] Lieberman, L. S. and Rosenbloom, A. L., "Ultrasound and Anthropometric Measurements of Body Composition in Children with Insulin Dependent Diabetes Mellitus (IDD)," *Pediatric Research*, Vol. 14, April 1980, pp. 577-907.

[21] Lieberman, L. S., Rosenbloom, A. L., Riley, W. J., and Silverstein, J. H., "Correlated Changes in Skin Thickness and Glycosylated Hemoglobin with Pump Administration of Insulin," *Clinical Research*, Vol. 28, Dec. 1980, p. 866A 5.

[22] Stouffer, J. R., "Relationship of Ultrasonic Measurements and X-rays to Body Composition," *Annals of the New York Academy of Sciences*, Vol. 110, Sept. 1963, pp. 31-39.

[23] Haymes, E. M., Lundegren, H. M., and Loomis, J. L., "Validity of the Ultrasonic Technique as a Method of Measuring Subcutaneous Adipose Tissue," *Annals of Human Biology*, Vol. 3, No. 3, May 1976, pp. 245-251.

[24] Booth, R. A. D., Goddard, B. A., and Paton, A., "Measurement of Fat Thickness in Man: A Comparison of Ultrasound, Harpenden Calipers and Electrical Conductivity," *British Journal of Nutrition*, Vol. 20, 1966, pp. 719-725.

[25] Borkan, G. A., Hults, D. E., Cardarelli, J., and Burrows, B. A., "Comparison of Ultrasound and Skinfold Measurements in Assessment of Subcutaneous and Total Fatness," *American Journal of Physical Anthropology*, Vol. 58, No. 3, July 1982, pp. 307-313.

[26] Bartrum, R. J. and Crow, H. C., *Gray-Scale Ultrasound: A Manual for Physicians and Technical Personnel*, W. B. Saunders, Philadelphia, 1977.

[27] Baker, M. L. and Dairymple, G. V., "Biological Effects of Diagnostic Ultrasound: A Review," *Radiology*, Vol. 126, Feb. 1978, pp. 479-483.
[28] Communication from the American Institute of Ultrasonic Medicine Bioeffects Committee, *Journal of Clinical Ultrasound*, Vol. 5, Feb. 1977, pp. 2-4.
[29] Turbak, G., "Missing: 100,000 Children a Year," *Reader's Digest*, July 1982, pp. 60-64.
[30] Krogman, W. M., "The Problem of 'Timing' in Facial Growth with Special Reference to the Period of the Changing Dentition," *American Journal of Orthodontics and Oral Surgery*, Vol. 37, 1951, pp. 253-276.
[31] Hoffman, N. Y., "Edith Potter, M.D., Ph.D.: Pioneering Infant Pathology," *Journal of the American Medical Association*, Vol. 248, No. 13, 1 Oct. 1982, pp. 1551-1553.

Address requests for reprints and additional information to
Gabrielle Hodson, M.A.
Graduate student
Department of Anthropology
University of Arizona
Tucson, AZ 85721