CASE REPORT

Tzipi Kahana,[1] *M.Sc. and Jehuda Hiss,*[1] *M.D.*

Positive Identification by Means of Trabecular Bone Pattern Comparison

REFERENCE: Kahana, T. and Hiss, J., **"Positive Identification by Means of Trabecular Bone Pattern Comparison."** *Journal of Forensic Sciences,* JFSCA, Vol. 39, No. 5, September 1994, pp. 1325–1330.

ABSTRACT: Positive identification of human remains is often achieved by comparing antemortem and postmortem radiographs. Usually, radiographs contain a number of markers that can serve as reference for comparison, one of these markers is the trabecular bone pattern depicted in the roentgenograms. In the present case, densitometric analysis of the trabecular bone pattern was used as the sole means of identification. Later on, two other methods confirmed the original positive identification.

KEYWORDS: physical anthropology, trabecular pattern, positive identification, human identification

The comparison of antemortem and postmortem radiographs for positive identification of human remains is a widely used procedure in forensic anthropology [*1,2*]. The technique was first documented in the literature in 1927 by Law and Culbert [*3*], who compared the morphology of air sinuses and air cells in antemortem and postmortem cranial radiographs and established positive identification.

The reliability of identifications based on cranial and postcranial radiographic markers, has been well established since then. These markers include: gross anatomic structures [*3–6*], general degenerative changes [*7*] trauma and evidence of medical intervention [*8*] and the trabecular bone pattern depicted on the radiographs [*1,9–11*].

In this paper, a case is reported, in which positive identification was established using the trabecular bone architecture of the first metacarpal and phalanx and was later confirmed by other means of identification.

Case Report

In July 1992, two terrorists died when the stolen car in which they were traveling burst in flames. When the bodies were recovered they were extensively charred, thus precluding

Received for publication 16 Dec. 1993; revised manuscript received 7 March 1994; accepted for publication 7 March 1994.

[1] Forensic Anthropologist, Israel Police Force and Director, respectively, The L. Greenberg Institute of Forensic Medicine, Tel-Aviv, Israel.

visual identification. Identification and necropsy of the two burned bodies were performed at the L. Greenberg Institute of Forensic Medicine. An anthropological profile of each body was submitted to the Israeli police department together with a complete set of fingerprints of one of the bodies and a thumb print of the other. The next day, the police submitted radiographs (Fig. 1) of the right and left thumbs of a terrorist on the wanted list, who fit one of the anthropological profiles provided by the forensic anthropologist.

Postmortem radiographs of the right thumb of the body in question were taken for comparison (Fig. 2) with the radiographs supplied by the police (the left hand was extensively damaged by the fire). The visual comparison of the trabecular pattern of the first metacarpal and distal phalanx of the right hand clearly indicated that the antemortem and postmortem radiographs belonged to the same individual.

The antemortem radiographs, which had been taken two years previously, showed no evidence of trauma or special peculiarities. For this reason, detailed comparisons were made of the internal structure of the bone. In order to compare the antemortem and postmortem evidence, the radiographs were taken to the Physical Anthropology Laboratory of the Hebrew University to be densitometrically examined with an Image Analyzer.

Materials and Methods

The Image analyzer is a PC based system with the following major components: a view table for radiographs; a CCD computer controlled video camera and control card; an IBM/PC AT computer with appropriate software developed by "Galai" technologies and specially adapted by Dr. Paul Zaslansky from the Hebrew University, Hadassah Dental School.

Each radiograph was scanned and stored in the computer memory. The scanning process, performed by the camera, involves the translation of the different shades of gray of the radiograph into numbers. In this way a computer image is produced in which darker or

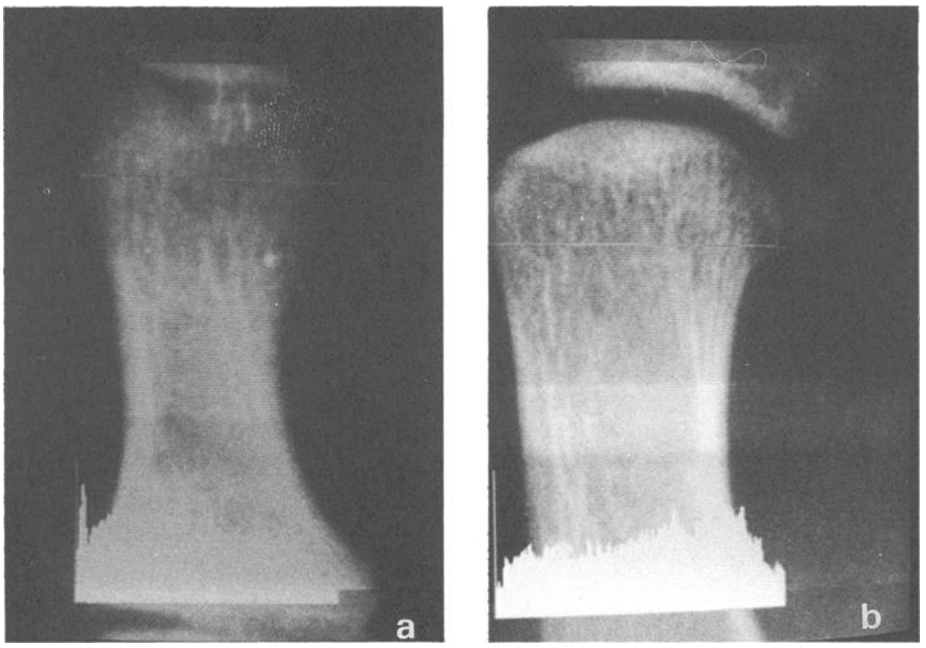

FIG. 1—*(a) Antemortem radiograph of the right proximal first phalanx; (b) antemortem radiograph of the right first metacarpal.*

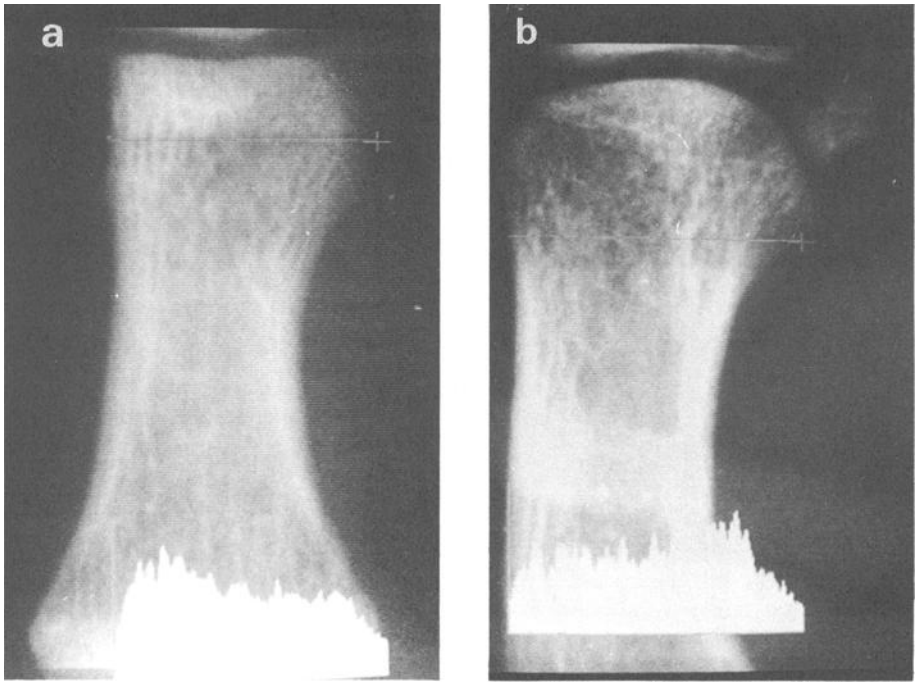

FIG. 2—*(a) Postmortem radiograph of the right proximal first; (b) postmortem radiograph of the right first metacarpal phalanx.*

lighter shades are represented by low or high values respectively (in the range of 0 to 254). Each computer image is stored as an array of numbers that can be statistically manipulated.

With the Cue4 analysis package, mathematical contrast enhancement operations were performed on the images.

Once the contrast was improved, a line along the proximal end of the first metacarpal and distal phalanx of each radiograph analyzed was selected and saved (Figs. 3 and 4). In

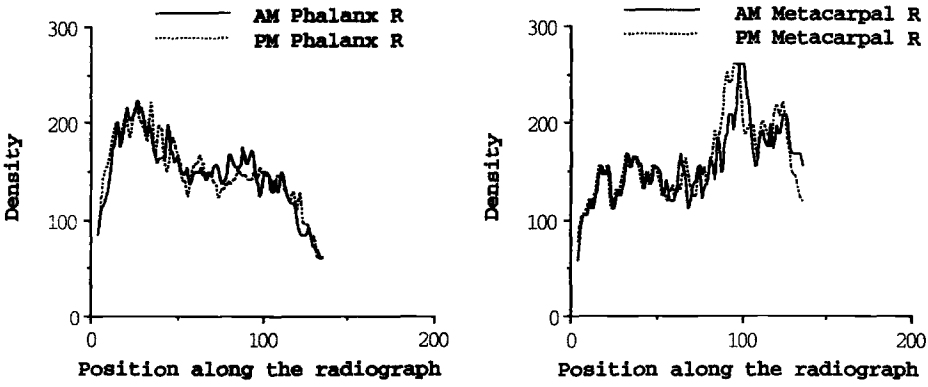

FIG. 3—*(a) Densitographs (line maps) of the antemortem and postmortem right proximal first phalanx; (b) densitographs (line maps) of the antemortem and postmortem right proximal first metacarpal.*

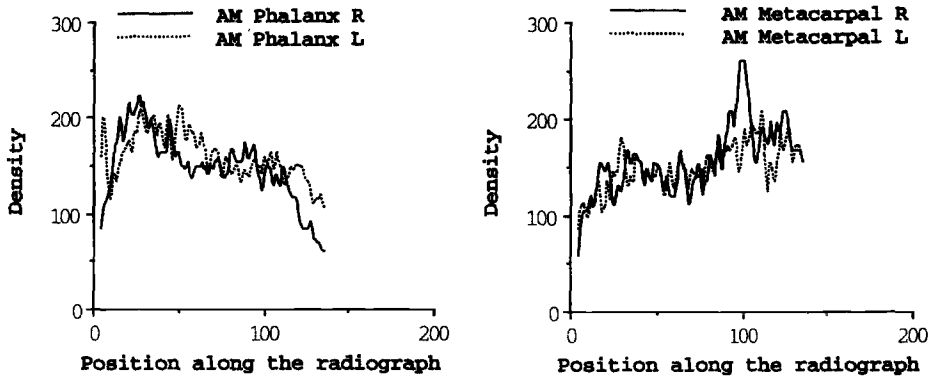

FIG. 4—*(a) Densitographs (line maps) of the antemortem left and right proximal first phalanx; (b) densitographs (line maps) of the antemortem left and right proximal first metacarpal.*

this manner, a profile of the trabecular bone pattern in each image was created. This profile (also known as a line map or a densitograph) transects distinct trabeculae [*12–13*]. The lines were selected at approximately 0.5 cm from the distal end of the first metacarpal and distal phalanx. The correlation between the different densitometric traces was examined through regression analysis.

For control purposes, the postmortem radiograph of the right hand was tested against both the right and left antemortem radiographs.

Results

Table 1 shows the correlation between the densitographs of the antemortem and postmortem radiographs of the right hand. A correlation of 0.90 was obtained for the phalanx and 0.81 for the metacarpal. The similarity between these densitographs can be evinced from the comparative graphs (Fig. 2). The correlation between the densitographs of the first metacarpal and distal phalanx of the right hand and the hand (antemortem) is also reported. The differences between the densitographs are shown on the comparative graph (Fig. 3). The correlation for both bones analyzed is less than 0.6 (the lowest correlation for densitographs of the same bone radiographed at different radiographic conditions is 0.6 [*14*].

TABLE 1—*Correlation between densitographs.*

	A.M. Right Phalanx	A.M. Right Metacarpal	A.M. Left Phalanx	A.M. Left Metacarpal	P.M. Right Phalanx	P.M. Right Metacarpal
A.M. Right Phalanx	1.0	...	...	...	...	...
A.M. Right Metacarpal	−0.272	1.0	...	...	...	...
A.M. Left Phalanx	0.507	−0.306	1.0	...	...	...
A.M. Left Metacarpal	−0.254	−0.432	−0.248	1.0	...	...
P.M. Right Phalanx	0.905	0.044	0.552	0.282	1.0	...
P.M. Right Metacarpal	0.073	0.816	0.429	0.559	0.128	1.0

Two days after the report of the positive identification by means of trabecular bone comparison was filed, the Israeli Police Department confirmed the identification by comparing the postmortem thumb print with antemortem prints that were on their files. Independently, a week later the Laboratory of Criminal Identification produced a positive identification from DNA analysis.

Discussion

Nowadays, radiographic comparisons are the most common technique used by forensic anthropologists for positive identification [*1,2*]. There are a number of reports in the literature on the markers used when making radiographic comparisons [*1–10, 15–20*]. Trabecular bone, however, is seldom used as a single marker since usually there are other remarkable features depicted in the radiographs.

In 1986 Van Der Stelt and colleagues proposed the use of trabecular bone pattern depicted in dental radiographs as a marker in forensic identifications [*9*]. Investigators comparing trabecular bone pattern from dental radiographs should be aware that the trabecular bone of the maxilla and mandible is affected by changes in the dentition, namely resorption of the alveolar bone due to extraction of teeth or periodontal disease.

Other factors that may affect comparison of the trabecular bone pattern are the radiographic conditions at which the radiographs were taken and the bone remodeling produced by age [*21*]. In a previous study designed to test the effect of the radiographic conditions on the depiction of the trabecular bone pattern [*14*], 10 radii were repeatedly radiographed under different radiographic conditions. The results of the study indicated that radiographs of the same bone taken at different settings (for example, intensity, time of exposure and angle) were more highly correlated (R = 0.8 to 0.6) than radiographs of different bones taken under the same conditions (R = 0.5 to 0.1).

Conclusion

Positive identification of the human remains is probably one of the most important steps in a necropsy. Forensic anthropologists often use radiographic comparisons for this purpose.

In this case, the only remarkable feature for comparison in the antemortem and postmortem radiographs was the trabecular bone pattern. The reliability of this marker for positive identification was tested through densitometric analysis and later confirmed by fingerprint and DNA comparisons.

References

[*1*] Atkins, L. and Potsaid, M. S., "Roentgenographic Identification of Human Remains," *Journal of the American Medical Association,* Vol. 240, No. 21, 1978, pp. 2307–2308.

[*2*] Birkby, W. and Rhine, S., "Radiographic Comparison of the Axial Skeleton for Positive Identification," *Presented at the Annual Meeting of the American Academy of Forensic Sciences,* Cincinnati, OH, 1983.

[*3*] Culbert, W. C. and Law, F. M., "Identification by Comparison of Roentgenograms of Nasal Accessory Sinuses and Mastoid Processes," *Journal of the American Medical Association,* Vol. 88, No. 4, 1927, pp. 1634–1636.

[*4*] Messmer, J. M. and Fierro, M. F., "Personal Identification by Radiographic Comparison of Vascular Groove Patterns of the Calvarium," *The American Journal of Forensic Medicine and Pathology,* Vol. 7, No. 2, 1986, pp. 159–162.

[*5*] Rhine, S. and Sperry, K., "Radiographic Identification by Mastoid Sinus and Arterial Pattern," *Journal of Forensic Sciences,* Vol. 36, No. 1, Jan. 1991, pp. 272–279.

[*6*] Marlin, D., Clark, M., and Standish, M., "Identification of Human Remains by Comparison of Frontal Sinus Radiographs: A Series of 4 Cases," *Journal of Forensic Sciences,* Vol. 36, No. 6, Nov. 1991, pp. 1762–1772.

[7] Sauer, N., Brantley, R. E., Baronders, D. A., "The Effect of Aging on the Comparability of Antemortem and Postmortem Radiographs," *Journal of Forensic Sciences,* Vol. 33, No. 5, Sept. 1988, pp. 1223–1230.

[8] Murphy, W. A., Spruill, F. G., and Gantner, G. E., "Radiographic Identification of Unknown Human Remains," *Journal of Forensic Sciences,* Vol. 25, No. 4, 1980, pp. 725–735.

[9] Van der Stelt, P., Webber, R., and Ruttimann, U., "Forensic Identification of Trabecular Patterns from Dental Radiographs," *Journal of Dental Research,* Vol. 65, Special Issue/Abstracts, 1986, p. 176 (abstract 56).

[10] Kade, H., Meyers, H., and Wahlke, J. E., "Identification of Skeletonized Human Remains by X-ray Comparison," *The Journal of Criminal Law, Criminology and Police Science,* Vol. 58, No. 2, 1967, pp. 261–264.

[11] Owsley, D. W. and Mann, R. W. "Personal Identity of Skeletonized Remains Using Abdominal and Pelvic Radiographs," *Journal of Forensic Sciences,* Vol. 37, No. 1, Jan. 1992, pp. 332–336.

[12] Israel, H. "Microdensitometric Analysis for the Study of Craniofacial Growth in the Living Subject," *American Journal of Physical Anthropology,* Vol. 27, No. 2, 1967, p. 236 (abstract 11).

[13] Israel, H., "Microdensitometric Analysis for the Study of Skeletal Growth and Aging in the Living Subject," *American Journal of Physical Anthropology,* Vol. 29, No. 2, 1968, pp. 287–294.

[14] Kahana, T., "The Reliability of the Trabecular Bone Pattern as a Bone Marker in Radiographs for Positive Identification," *Presented at the Annual Meeting of the American Academy of Forensic Sciences,* Boston, 1993.

[15] Merz, W. and Schenk, R. K., "Quantitative Structural Analysis of Human Cancellous Bone," *Acta Anatomica,* Vol. 75, No. 1, 1970, pp. 54–66.

[16] Buchner, A., "The Identification of Human Remains," *International Dental Journal,* Vol. 35, No. 4, 1985, pp. 307–311.

[17] Schwartz, T. and Woolridge, E. D., "The Use of Panoramic Radiographs for Comparison in Cases of Identification," *Journal of Forensic Sciences,* Vol. 31, No. 1, 1976, pp. 154–146.

[18] Sanders, I., Woesner, M. E., Ferguson, R. A., and Noguchi, T. T., "A New Application of Forensic Radiology: Identification of Deceased from a Single Clavicle," *American Journal of Roentgenology, Radium Therapy and Nuclear Medicine,* Vol. 115, No. 3, 1972, pp. 619–622.

[19] Ubelaker, D. H., "Positive Identification of American Indian Skeletal Remains from Radiograph Comparison," *Journal of Forensic Sciences,* Vol. 35, No. 2, 1990, pp. 466–472.

[20] Hyma, B. A. and Rao, V. J., "Evaluation and Identification of Dismembered Human Remains," *The American Journal of Forensic Medicine and Pathology,* Vol. 12, No. 4, 1991, pp. 291–299.

[21] Compston, J. E., Mellesh, R. W. E., Croucher, P., and Newcombe, R., "Structural Mechanisms of Trabecular Bone Loss in Man," *Bone and Mineral,* Vol. 6, No. 3, 1989, pp. 339–350.

Address requests for reprints or additional information to
Tzipi Kahana
Greenberg Institute of Forensic Medicine
67 Ben Zvi Blvd.
Tel-Aviv 61490
Israel