CASE REPORT

Daniel Rougé,[1] M.D.; Norbert Telmon,[1] M.D.; Philippe Arrue,[2] M.D.; Georges Larrouy,[3] M.D.; and Louis Arbus,[1] M.D.

Radiographic Identification of Human Remains Through Deformities and Anomalies of Post-Cranial Bones: A Report of Two Cases

REFERENCE: Rougé, D., Telmon, N., Arrue, P., Larrouy, G., and Arbus, L., "**Radiographic Identification of Human Remains Through Deformities and Anomalies of Post-Cranial Bones: A Report of Two Cases,**" *Journal of Forensic Sciences*, JFSCA, Vol. 38, No. 4, July 1993, pp. 997–1007.

ABSTRACT: Human remains can be identified radiographically by anomalies and deformities of the post-cranial bones when there are no old fractures and the cranium and extremities are not available. These anomalies and deformities of the sternum, vertebrae, sacrum and innominate bone are often protected from damage by scavengers. We report their use to exclude a proposed identity in one case and to confirm identity in another case. The value and number of these criteria and their pathogenesis is discussed with reference to their prevalence and their expression of inter- and intraindividual variability.

KEYWORDS: physical anthropology, human identification, X-ray analysis, vertebra, sacrum, xiphoid process, innominate bone, post-cranial bones

Numerous methods have been developed for determining identity through radiographic examination of bone remains [*1*]. However, we have mainly concentrated on the cranium, and in particular, on the mastoid [*2,3*], the mastoid sinus [*4*], the frontal sinus [*5–7*] or the temporal bone [*8*]. In several cases, positive identification has been possible using old fractures of the face [*9,10*] or the long bones [*11,12*], or sequelae of surgical procedures [*13*]. But in some cases the skull and mandible have disappeared and the available bones show no trace of fracture.

Anomalies and deformities of the post-cranial skeleton have been relatively rarely studied in isolated cases of positive identification if mass disasters are excluded [*1,12,14,15*]. The extremities that could be used [*1,16,17*] have sometimes been damaged by animals [*18,19*] and it is mainly in the long bones [*20*], the vertebrae [*21,22*], the pelvis [*23–25*]

Received for publication 17 Sept. 1992; revised manuscript received 24 Nov. 1992; accepted for publication 30 Nov. 1992.

[1]Lecturer and Attending Physicians, and Head of Department, respectively, Department of Forensic Medicine, Rangueil University Hospital, Toulouse Cedex, France.

[2]Attending Physician, Department of Radiology, Rangueil University Hospital, Toulouse, France.

[3]Director of Anthropological Studies, Department of Parasitology, Purpan University Hospital, France.

and the thorax [26,27] that we may hope to observe bone anomalies or deformities that can be compared with antemortem images [28]. Some authors have observed anomalies of the clavicle [29], patella [30], sesamoid bone [31] and scapula [32,33] allowing positive identification in individual cases.

The vertebrae, sacrum, innominate bone, and sternum are normally well protected from damage by animals [18,19]. In these two case reports, we were able to exclude a proposed identity in one case and to confirm identity in a second case, based on comparison of anomalies and deformities observed in antemortem and postmortem radiographs of these bones.

Case Reports

Case 1

Bone remains were discovered in September 1990 by walkers on a beach on Reunion Island in the Indian Ocean. The remains were easily identified as human as the four last lumbar vertebrae, the pelvis, both femurs and tibias were intact. Unfortunately the upper part of the body (dorsal and cervical vertebrae, ribs, skull) and the feet were missing. No clothing was found. Police investigations revealed that a man of German nationality had disappeared at sea 15 days earlier. It was learned from the man's family that he had suffered from sciatica two years before and had undergone a lumbosacral CT scan in November 1988. These images were examined.

Analysis of Remains—This suggested the remains were those of a Caucasian male: crural index 80.5 [34,35], innominate bone and femur [36,37], pelvis, femur, tibia [1]. The pubis presented male criteria [38,39]: absence of ventral arc [40], subpubic concavity and medial aspect of the ischiopubic ramus [41]. The posterior aspect of the pelvis had the same sexual characteristics: acetabular-sciatic index 110.52 [42]. The age of the subject at the time of death was compatible with that of the missing man (47 years). The pubis was phase IV [38], the auricular surface phase V [43], the radiographic aspect of the spongy bone and the femoral cortex phase III [44]. Height calculated from the femur and tibia [45] was 5 ft 8 ins ± 3 ins and from the femur and the lumbar spine 174.24 ± 2.35 cm [46] (the height of L5 was estimated). This was compatible with the height of the missing person: 5 ft 9 in or 175 cm. No signs of fracture or of bites from marine predators [47] were observed on the remains. The cause of death was unknown.

Radiographic Comparison—After examination of the antemortem images, a scan was taken in order to obtain comparable images of the bone remains. This scan provided four elements of information that made it possible to exclude the proposed identity:

—two acquired morphological deformities, absent in the missing man, were seen on the scan of the bone remains: an anterior osseous bridge between L2-L3 and intra-body disk herniation of L4 (Figs. 1*a*, 1*b*).

—two genetic anomalies were different: the missing man had a lumbar canal that was narrowed by the presence of short pedicles (Fig. 2*a*) but this was not observed in the scan of the remains (Fig. 2*b*); lastly, the direction of the partes laterali sacri was different in the two scans (Figs. 3*a*, 3*b*).

Case 2

In May 1991, a warden in charge of surveillance and protection of vultures in the mountainous Cévennes area of France noticed a Ford Fiesta car at the bottom of a 20 m deep ravine. A few meters lower, a clothed skeleton was discovered with the upper part of the body missing (head, cervical vertebrae, upper limbs). After a careful search

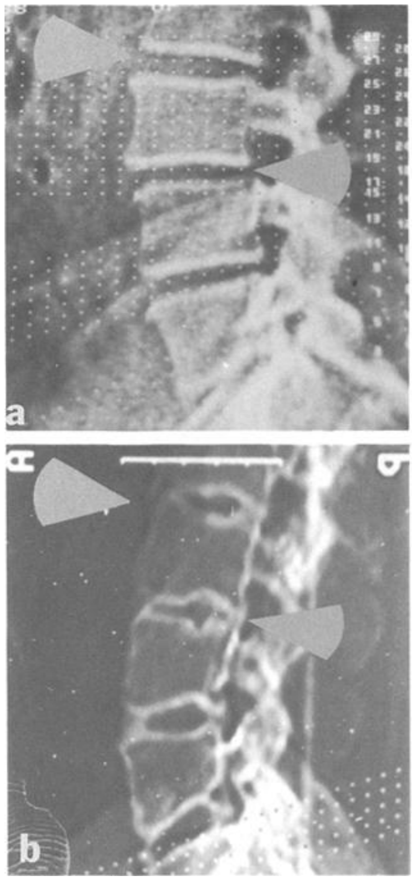

FIG. 1—*Case 1: bony bridge between L2-L3 and intra-body disk herniation at the upper vertebral plateau of L4 on a lateral view of the spine* (b). *These are absent on the antemortem image* (a).

of the ravine, some small fragments of the base and the dome of the cranium were found 6-, 8-, 50 m, respectively from the skeleton. Police investigation revealed that the car's owner had been missing since September 1989. The family of the missing man confirmed that the clothing on the skeleton corresponded to that worn by their relative the day he disappeared. At his home, anterior and lateral X-rays of the thorax dated April 1979 and an anterior pelvic X-ray dated October 1982 were found.

Analysis of Remains—Analysis suggested the remains were those of a white male [*35,36*]: crural index 81.3 [*34*]. The pubis presented the male characteristics of Phenice [*40,41*]. The acetabular-sciatic index of 107.8 was male [*42*]. Age was compatible with that of the missing man at the time of disappearance (61 years): pubis phase V [*38*], right fourth rib phase VIII [*48*], auricular surface phase VI [*43*], radiological appearance of the spongy bone and of the femoral cortex phase III [*44*]. Height calculated from the femur was 66 ± 3 in [*45*] and from the femur and the lumbar spine 168 ± 2.3 cm [*46*]. This was compatible with the height of the missing man (170 cm). The bones showed signs of damage by scavengers (probably by the vultures, which were numerous in the area), in particular the left femur, the calcaneums and the ribs [*18,19*]. The cause of death was unknown and there were no signs of old fractures.

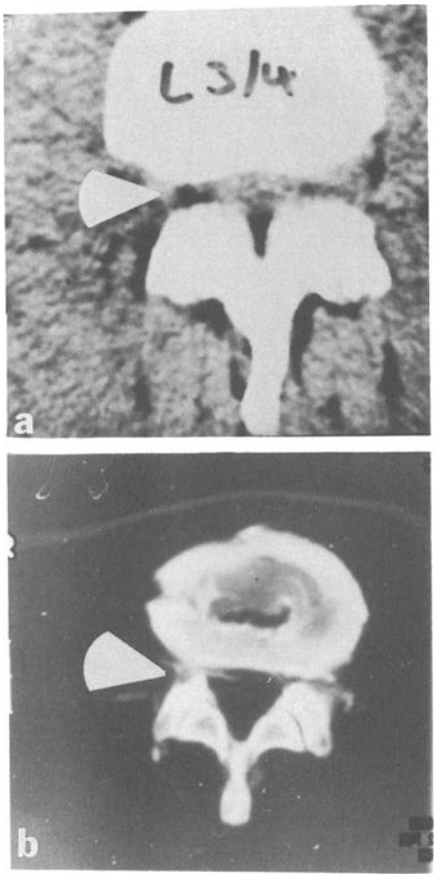

FIG. 2—*Case 1: narrow lumbar canal, due to short pedicles, on a CT scan image of L3-L4* (a). *The postmortem image shows a lumbar canal of normal dimensions. Intrabody disk herniation is clearly seen* (b).

Comparative Radiography—X-rays of the bone remains were taken in identical positions to the antemortem lateral view of the sternum and anterior view of the pelvis. Three anomalies and deformities were found on both the antemortem and postmortem images:

—first, the sternal xiphoid process was the same in length and in general shape. Superposition of the two images showed only accentuation of degenerative elements compatible with the elapsing of twelve years between the two images (Figs. 4*a*, 4*b*). The sternal fracture visible in Fig. 4*b* is above the xiphoid deformation and does not modify its appearance.

—second, a trapezoidal bony spicule was observed on the ischiopubic branch of the left innominate bone. This spicule was also present on the pelvic X-rays taken nine years before the disappearance (Figs. 5*a*, 5*b*, 6*a*, 6*b*).

—third, a flattened plane on the internal part of the obturator foramen was visible on both X-rays.

Positive identification was possible because of the combination of these three radiological elements, concordance of reconstructive identification and absence of incompatible elements.

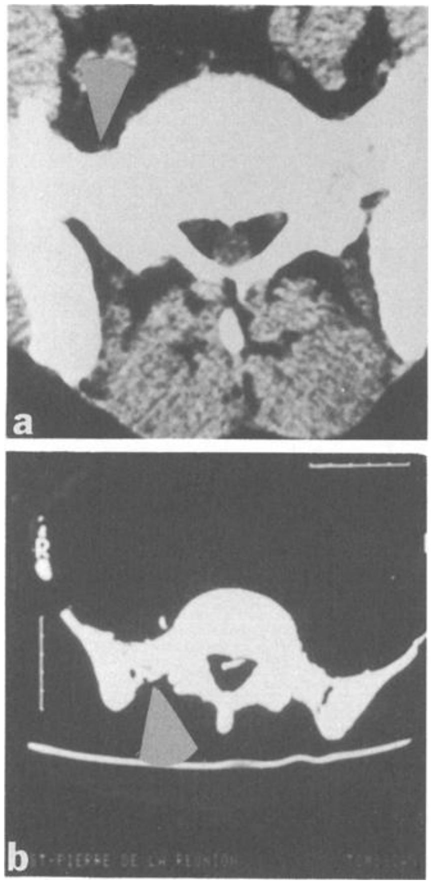

FIG. 3—*Case 1: the partes laterales sacri are directed forwards and outwards on the antemortem CT scan* (a), *whereas they are directed backwards and outwards on the postmortem image* (b).

Discussion

Anomalies and Deformities of the Post-Cranial Bones

The value of the criteria necessary for positive identification differs from that required for exclusion.

In order to exclude an identity, the prevalence of the criterion is of little importance as it is only necessary for its presence or absence to be incompatible with normal development [*21*]. This certainty is indispensable before any positive comparative identification. For positive identification to be possible, there must be no element on the postmortem scan that excludes an identity because it could not have developed from the elements on the antemortem scan. Morphological anomalies and deformities may be genetic or acquired and the prevalence of each must be taken into account [*30,32,33*].

Unlike an exceptional anomaly, a frequent anomaly affords little information in support of a proposed identity. However, if no rare anomaly is present, a presumed identity can be narrowed down by the presence of an association of frequent anomalies. The association of unrelated morphological anomalies has a theoretical prevalence equal to the

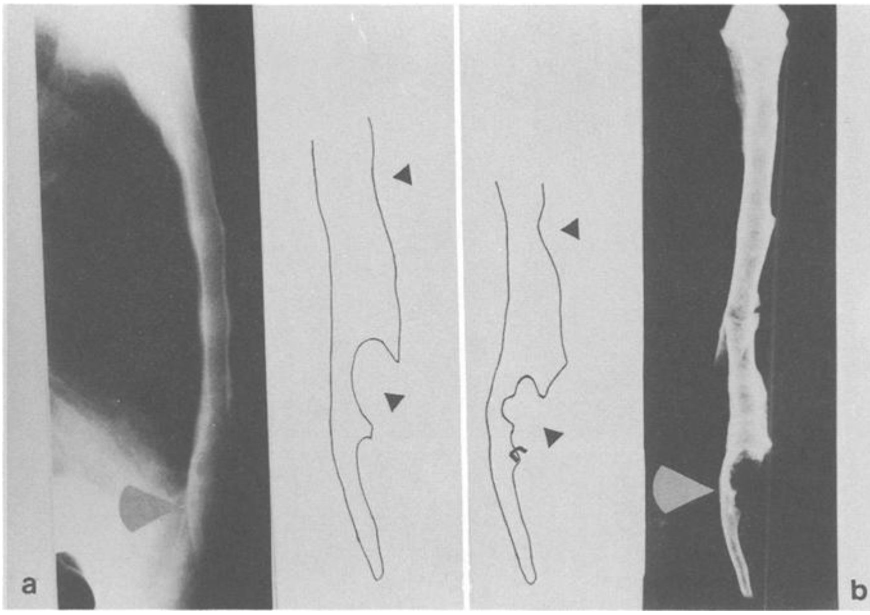

FIG. 4—*Case 2: the shape and length of the xiphoid process are the same on the antemortem lateral view of the sternum* (a) *and on the postmortem view* (b).

product of the various prevalences. In fact, the association of several frequent anomalies is rare. It is not possible to give the number of anomalies necessary for positive identification as this number increases with the prevalence of the anomalies and decreases with their rarity.

However, Krogman and Iscan [*1*], Singleton [*14*] and Brown [*15*] report the necessity of comparing nine characteristics of the pelvis and the vertebrae and 13 characteristics of the thorax in radiographic identification after the "Noronic" disaster. Zugibe et al. [*20*] used six points in the tibia and the left knee for the identification of journalist John J. Sullivan. Moser and Wagner [*25*] used the innominate bone to match trabecular pattern and vascular grooves in the identification of victims of severe trauma.

The Thorax

The thorax is reported by Murphy [*28*] as being an area that often allows positive radiographic identification (16 of 50 cases) but calcification of chrondrocostal cartilage appears to be the criterion most frequently used [*26–28*].

On the other hand, we are not aware of any other case of radiographic identification using the xiphoid process. We have studied the important scientific work of Zimmer [*49*] on anatomical variations of the xiphoid process. The distinctive shape we observed in our Case 2 is not described in this work. In addition, we have studied the xiphoid processes of 86 bodies during forensic autopsies and we have never observed this concave and irregular shape nor such a long xiphoid process. The shape is so indented that several points can be superposed as in the mastoid sinus [*4*] or the frontal sinus [*6,7*]. An explanation of this deformity has been put forward by Lane [*50*] as it is often found in shoemakers who hold the toe of the shoe against the sternum. Kennedy [*51*] reports the deformity as being "a skeletal marker of occupational stress."

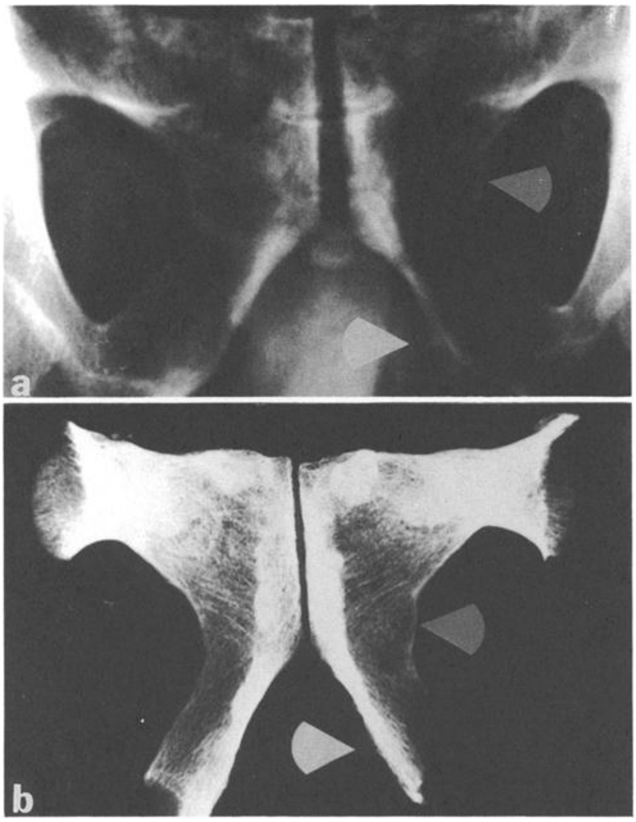

FIG. 5—*Case 2: a trapezoidal bony spicule can be seen on the ischiopubic branch of the left hipbone in the same location on the antemortem image* (a) *and the postmortem image* (b). *A flattened plane on the internal part of the obturator foramen is found on the antemortem image* (a) *and the postmortem image* (b).

The Pubis

The pubis is reported only once by Murphy [*28*] as being a region allowing radiographic identification. However it is not infrequent for subjects to have had pelvic X-rays for medical reasons. The pelvis has been used for identification in some cases in mass disasters [*14,15*]. Markert [*23,24*] has thoroughly studied the elements of the pelvis, which can be of use in identification and in our case of positive identification (Case 2) the association of the same shape and the same location of the bony spicule on the left ischiopubic branch (acquired deformity) and of the flattened inner part of the left obturator foramen (genetic anomaly) is very rare. It is in fact an association of a criterion of interindividual variation (the obturator foramen) and a criterion of intraindividual variation (periosteal apposition).

Vertebral Anomalies

Vertebral anomalies and deformities were reported by Murphy [*28*] as having led to positive identification in eight of 50 cases. Posterior anomalies of the cervical and dorsal vertebrae (transverse process and unbifurcated dorsal spine) led to positive identification

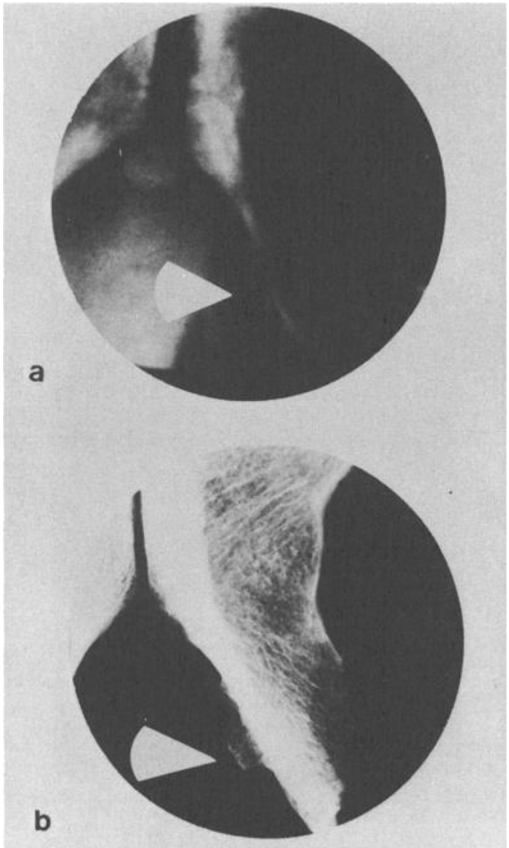

FIG. 6—*Case 2: details of shape and location of the left ischiopubic spicule on an enlargement of the antemortem image* (a) *and the postmortem image* (b).

in a case in Kansas [*22*]. Anatomic and arthritic differences seen in cervical vertebrae six and seven were used by Murphy to exclude a possible identity [*21*]. Roche [*52*] showed the incidence of osteophytosis and osteoarthritis in 419 skeletonized vertebral columns. However, it seems that no personal identification through CT scan has yet been published although this is a rapidly expanding imaging technique. The value of the scan is that the spine and sacrum can be observed on a horizontal plane. Thus, in Case 1 it was possible to observe the difference in orientation of the partes laterales sacri and the difference in size of the lumbar canal due to the dimension of the pedicles.

Intrabody disk herniation of L4 could be seen on a lateral view and a horizontal view. This is a acquired deformity due to Scheuermann's disease, which has an onset between 14 and 17 years and whose development ends between 20 and 22 years [*53*]. It may be linked with nutritional disorders or the carrying of heavy loads but may also be due to individual predisposition [*53,54*]. Intrabody disk herniation is valuable for comparative radiographic identification as it is a pathological deformity whose development is limited in time. In fact, pathological deformities are intrinsically discriminatory as they vary from one individual to another (interindividual variation) and also vary over time in a given individual (intraindividual variation). These anomalies have the greatest discriminatory value as long as the duration and period of development are known in order to allow accurate comparison when a long period has elapsed between the ante- and postmortem images.

Conclusion

Although the cranium and old fractures are the elements most frequently used for positive identification [*1,7,13,28,31*], anomalies and deformities of the post-cranial bones should not be neglected in the identification of bone remains [*1,20,23–26,30,33,52*]. These bones are often protected from damage by animals [*18,19*], in particular the sternum [*49*], the vertebrae and the sacrum [*21,22*].

It is important that no information should be lost when the forensic pathologist receives the bones. As stressed by Stewart [*12*], "special care must be taken in such cases not to miss a significant specific trait through failure to get a clear look at the bones." It also seems useful to take the postmortem images after having examined the antemortem images available.

All available X-rays of the post-cranial bones must be studied. Accumulated elements that are of little discriminatory value because of their high prevalence are of value if they are numerous [*14,15*].

These two case reports show that the association of criteria of the post-cranial bones, expressing interindividual and intraindividual variation, is highly discriminatory in radiographic identification.

Acknowledgments

The authors wish to thank Dr. Judy Myers Suchey, Professor of Anthropology at the University of Fullerton, California, for her helpful advice on the writing of this paper, the police of St Pierre des Avirons, Reunion Island for their cooperation, Jean-François Brugne for photography and Nina Crowte for translation.

References

[*1*] Krogman, W. M. and Iscan, M. Y., "Radiographic Analysis," *The Human Skeleton in Forensic Medicine*, Charles C Thomas, Springfield, IL, 1986.

[*2*] Culbert, W. L. and Law, F. M., "Identification by Comparison with Roentgenograms of Nasal Accessory Sinuses and Mastoid Processes," *Journal of the American Medical Association*, Vol. 88, No. 21, 1927, pp. 1634–1636.

[*3*] Smith, S., "Study in Identification: No. 3," *Police Journal of London*, Vol. 12, 1939, pp. 271–285.

[*4*] 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.

[*5*] Asheron, N., "*Identification by Frontal Sinus Prints. A Forensic Medical Pilot Survey*," H. K. Lewis, London, 1965.

[*6*] Marlin, D. C., Clark, M. A., and Standish, S. M., "Identification of Human Remains by Comparison of Frontal Sinus Radiographs: A Series of Four Cases," *Journal of Forensic Sciences*, Vol. 36, No. 6, November 1991, pp. 1765–1772.

[*7*] Ubelaker, D. H., "Positive Identification from the Radiographic Comparisons of Frontal Sinus Patterns," *Human Identification: Case Studies in Forensic Anthropology*, T. A. Rathbun and J. E. Buikstra, Eds., Charles C Thomas, Springfield, IL, 1984.

[*8*] Maples, W. R., "Identification Based on Pathology of the Temporal Bone," presented at the Annual Meeting of the American Academy of Forensic Science, Washington D.C., Feb. 1976.

[*9*] Prinsloo, I., "The Identification of Skeletal Remains in Regina versus K. and Another: the Howick Falls (Natal) Murder Case," *Journal of Forensic Medicine*, Vol. 1, 1953, pp. 11–17.

[*10*] Salgado, M. S. L., De Alwis, L. B. L., and Perera, N., "Identification from Skeletal Remains," *Forensic Science International*, Vol. 36, 1988, pp. 73–80.

[*11*] Dutra, F. A., "Identification of Persons and Determination of Cause of Death from Skeletal Remains," *Archives of Pathology*, Vol. 38, 1944, pp. 339–349.

[12] Stewart, T. D., "Traits Peculiar to the Individual," *Essentials in Forensic Anthropology*, Charles C Thomas, Springfield, IL, 1979, pp. 247–251.
[13] Sauer, N. J. and Dunlap, S. S., "The Asymmetrical Remodelling of Two Neurosurgical Burr Holes: A Case Study," *Journal of Forensic Sciences*, Vol. 30, No. 3, July 1985, pp. 953–957.
[14] Singleton, A. C., "The Roentgenological Identification of Victims of the "Noronic" Disaster," *American Journal of Roentgenology, Radium Therapy and Nuclear Medicine*, Vol. 66, 1951, pp. 375–384.
[15] Brown, T. C., Delaney, R. J., and Robinson, W. L., "Medical Identification in the "Noronic" Disaster," *Journal of the American Medical Association*, Vol. 148, 1952, pp. 621–627.
[16] Kade, H., Meyers, H., and Wahlke, J. E., "Identification of Skeletonized Remains by X-ray Comparison," *Journal of Criminal Law, Criminology and Police Science*, Vol. 58, No. 2, 1967, pp. 261–264.
[17] Atkins, L. and Potsaid, M. S., "Roentgenographic Identification of Human Remains," *Journal of the American Medical Association*, Vol. 240, No. 21, Nov. 1978, pp. 2307–2308.
[18] Morse, D., Duncan, J., and Stoutamire, J. W., "*Handbook of Forensic Archeology*," Rose Printing Company, Tallahassee, Florida, 1983.
[19] Haglund, W. D., Reay, D. T., and Swindler, D. R., "Tooth Mark Artifacts and Survival of Bones in Animal Scavenged Human Skeletons," *Journal of Forensic Sciences*, Vol. 33, No. 4, July 1988, pp. 985–997.
[20] Zugibe, F. T., Taylor, J., Weg, N., Di Bennardo, R., Costello, J. T., and DeForest, P., "Metropolitan Forensic Anthropology Team (MFAT), Case Studies in Identification. 3. Identification of John J. Sullivan, the Missing Journalist," *Journal of Forensic Sciences*, Vol. 30, No. 1, Jan. 1985, pp. 221–231.
[21] Murphy, W. A. and Gantner, G. E., "Radiologic Examination of Anatomic Parts and Skeletonized Remains," *Journal of Forensic Sciences*, Vol. 27, No. 1, Jan. 1982, pp. 9–18.
[22] Frayer, D. W. and Bridgens, J. G., "Stab Wounds and Personal Identity Determined from Skeletal Remains: A Case from Kansas," *Journal of Forensic Sciences*, Vol. 30, No. 1, Jan. 1985, pp. 232–238.
[23] Markert, K., Kruger, H., Wirth, I., Radam, G., and Gertler, A., "Röntgenidentifikation vom adulten Beckenskelett bei Vorliegen von Intravitalaufnahmen aus dem Kindesalter," *Radiologia Diagnostica*, Vol. 22, 1981, pp. 646–650.
[24] Markert, K., Lehmann, R., Strauch, M., Mattig, W., and Wirth, I., "Der Schädel als Identifizierungsobjekt im Röntgenbildvergleich," *Radiologia Diagnostica*, Vol. 22, 1981, pp. 764–771.
[25] Moser, R. P. and Wagner, G. N., "Nutrient Groove of the Ilium, a Subtle but Important Forensic Radiographic Marker in the Identification of Victims of Severe Trauma," *Skeletal Radiology*, Vol. 19, 1990, pp. 15–19.
[26] Martel, W., Wicks, J. D., and Hendrix, R. C., "The Accuracy of Radiologic Identification of Humans Using Skeletal Landmarks: A Contribution to Forensic Pathology," *Radiology*, Vol. 124, Sept. 1977, pp. 681–684.
[27] Teige, K. and Ahrberg, B., "Röntgenidentifikation von leichen Anhand der knockernen Strukturen der vonderen Brustwand," *Archive für Kriminologie*, Vol. 168, No. 3–4, 1981, pp. 78–86.
[28] Murphy, W. A., Spruill, F. G., and Gantner, G. E., "Radiologic Identification of Unknown Human Remains," *Journal of Forensic Sciences*, Vol. 25, No. 4, Oct. 1980, pp. 727–735.
[29] 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, July 1972, pp. 619–622.
[30] Riddick, L., Brogdon, B. G., Laswell-Hoff, J., and Delmas, B., "Radiographic Identification of Charred Human Remains through Use of the Dorsal Defect of the Patella," *Journal of Forensic Sciences*, Vol. 28, No. 1, Jan. 1983, pp. 263–367.
[31] Knight, B., "The Examination of Skeletal Remains," *Legal Medicine*, 1985, pp. 1–19.
[32] Ubelaker, D. H., "*Positive Identification in Human Skeletal Remains: Excavation, Analysis, Interpretation*," *2nd Ed.* Taraxacum, Washington, D.C., 1989, pp. 126–129.
[33] 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.
[34] Martin, R., "*Lehrbuch der Anthropologie*," Fischer, Jena, 1928.
[35] St. Hoyme, L. E. and Iscan, M. Y., "Determination of Sex and Race: Accuracy and Assumptions," *Reconstruction of Life from the Skeleton*, Alan R. Liss Inc., New York, 1989, pp. 53–93.
[36] Di Bennardo, R. and Taylor, J. V., "Multiple Discriminant Function Analysis of Sex and Race in the Postcranial Skeleton," *American Journal of Physical Anthropology*, Vol. 61, 1983, pp. 305–314.

[37] Schulter-Ellis, F. P. and Hayek, L. C., "Predicting Race and Sex with an Acetabulum-Pubis Index," *Collegium Anthropologica*, Vol. 8, 1984, pp. 155–162.
[38] Katz, D. and Suchey, J. M., "Age Determination of the Male Os Pubis," *American Journal of Physical Anthropology*, Vol. 69, 1986, pp. 427–435.
[39] Katz, D. and Suchey, J. M., "Race Differences in Pubic Symphyseal Aging Patterns in the Male," *American Journal of Physical Anthropology*, Vol. 80, 1989, pp. 167–172.
[40] Sutherland, L. D. and Suchey, J. M., "Use of the Ventral Arc in Pubic Sex Determination," *Journal of Forensic Sciences*, Vol. 36, No. 2, March 1991, pp. 501–511.
[41] Phenice, T. W., "A Newly Developed Visual Method of Sexing the Os Pubis," *American Journal of Physical Anthropology*, Vol. 30, 1969, pp. 297–302.
[42] Sauter, M. R. and Privat, F., "Sur un Nouveau Procédé Metrique de Détermination Sexuelle du Bassin Osseux," *Bulletin de la Société Suisse d'Anthropologie et d'Ethnologie*, Vol. 31, 1955, pp. 60–84.
[43] Lovejoy, C. O., Meindl, R. S., Pryzbeck, T. R., and Mensforth, R. P., "Chronological Metamorphosis of the Auricular Surface of the Ilium: A New Method for the Determination of Adult Skeletal Age at Death," *American Journal of Physical Anthropology*, Vol. 68, 1985, pp. 15–28.
[44] Acsadi, G. and Nemeskéri, J., "*History of Human Life Span and Mortality*," Akademiai Kiado, Budapest, 1970.
[45] Trotter, M. and Gleser, G. C., "A Re-evaluation of Stature Based on Measurements Taken during Life and of Long Bones after Death," *American Journal of Physical Anthropology*, Vol. 16, 1958, pp. 79–123.
[46] Fully, G. and Pineau, H., "Détermination de la Stature au moyen du Squelette," *Annales de Médecine Légale*, Vol. 40, 1960, pp. 145–154.
[47] Rathbun, T. A. and Rathbun, B. C., "Human Remains Recovered from a Shark's Stomach in South Carolina," *Journal of Forensic Sciences*, Vol. 29, No. 1, Jan. 1984, pp. 269–276.
[48] Iscan, M. Y., Loth, S. R., and Wright, R. K., "Age Estimation from the Rib by Phase Analysis: White Males," *Journal of Forensic Sciences*, Vol. 29, No. 4, Oct. 1984, pp. 1094–1104.
[49] Zimmer, E. A., "*Das Brustbein und seine Gelenke*," Georg Thieme Verlag, Liepzig (UBV), 1939.
[50] Lane, W. A., "The Anatomy and Physiology of the Shoemaker," *Journal of Anatomy and Physiology*, Vol. 22, No. 4, 1988, pp. 593–628.
[51] Kennedy, K. A. R., "Skeletal Markers of Occupational Stress," *Reconstruction of Life from the Skeleton*, Alan R. Liss Inc., New York, 1989, pp. 129–160.
[52] Roche, S. L., "Incidence of Osteophytosis and Osteoarthritis in 419 Skeletonzied Vertebral Columns," *American Journal of Physical Anthropology*, Vol. 15, 1957, pp. 433–434.
[53] Fully, G., "Réflexions et Essai de Pathogénie Vertébrale à partir de Constatations Anatomiques faites sur des Squelettes de Déportés Morts dans les Camps de Concentration Allemands," *Annales de Médecine Légale*, Vol. 43, 1963, pp. 150–158.
[54] Kelley, M. A., "Intervertebral Osteochondrosis in Ancient and Modern Populations," *American Journal of Physical Anthropology*, Vol. 59, No. 3, 1982, pp. 271–279.

Address requests for reprints or additional information to
Daniel Rougé, M.D.
Service de Médecine Légale
CHU Rangueil
F-31054 Toulouse Cedex
France