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Radiographic Identification of Unknown Human Remains and Interpreter Experience Level

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ABSTRACT: The use of radiographs as a means of identification of unknown remains is a well-established method as performed by radiologists, forensic anthropologists, or pathologists. We devised a test to determine whether the degree of radiographic and medical knowledge of a film interpreter correlates with the degree of accuracy in making comparisons of radiographic unknowns. Three groups considered to be distinctly different in their level of medical knowledge and radiographic interpretive skills were chosen to evaluate forensic identification cases. Although all three groups identified a majority of cases correctly, none were completely accurate. The group with training in radiographic interpretation performed significantly better. Our study supports the need for trained interpreters in cases of forensic identification.

KEYWORDS: physical anthropology, human identification, radiographs

The use of radiographs as a means of identification of unknown human remains as performed by radiologists, pathologists or forensic anthropologists is well established in both the radiologic and forensic literature [*1–14*]. In many cases the forensic pathologist or anthropologist is able to make a positive identification of a deceased by visual features, personal effects, fingerprints or dental records. In cases of fire, severe decomposition or mutilation radiographic identification assumes a predominant role, as the skeleton of the deceased, at least in part, usually will survive when other identifying characteristics will not [*1,3,4,6,8,13*].

Radiographs present unique skeletal anatomic information analogous to a fingerprint and provide for a reliable means of identification when comparison radiographs are available [*1–14*]. Nearly every bone in the body has been used for identification of unknown remains and many reports describe a positive identification based on a single distinctive skeletal feature [*1,3,4,6*], although radiographic identification is strengthened by finding multiple points of comparison. In the published cases the radiographic interpreters were diagnostic radiologists or forensic pathologists or anthropologists, but in many instances an experienced film interpreter may not be available.

We devised a radiographic test to determine whether the level of knowledge and

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experience of the film interpreter correlates with the degree of accuracy in making comparisons of radiographic unknowns.

Materials and Methods

Ten radiographs in standard projections were chosen as forensic identification cases, some of which were actual forensic cases and some of which were obtained randomly from the radiographic files at the Medical College of Virginia. The projections included frontal skull, lateral skull (two cases), frontal cervical spine, female pelvis, lateral foot, frontal hand, frontal lower leg, and frontal chests (two cases, male and female). For each of the ten radiographs selected, four comparison radiographs of similar projection were selected from the department's patient radiographic files. It was attempted to find comparison films that closely resembled the test case both in size and overall shape to ensure that the identification would be challenging to all of the participants. One of the comparison radiographs was a separate radiograph of the same individual chosen to be the test case so that each test case had a proven correct match. The films were displayed, one identification case per panel, on an illuminated rollerboard.

Three groups were selected as film interpreters. Group I consisted of high school seniors participating in the medical division of the Virginia Governor's School for the Gifted. Group II consisted of fourth year medical students in the general radiology elective. Group III included diagnostic radiology residents of all levels of experience. These groups were considered to be distinctly different with respect to their medical knowledge and radiologic interpretive skills. Group I had no formal medical or diagnostic radiology training. Group II had four years of formal medical training, but only elementary diagnostic radiology training. Group III had four years of formal medical training and from a few months to years of specialized training in diagnostic radiology.

Each interpreter was tested individually by one of the authors and was allowed five minutes to evaluate each case. The nature of the test was explained verbally and each interpreter was provided with a brief typewritten description of the purpose and method of forensic radiologic identification immediately prior to the test. The interpreters were not allowed to handle or bright light the test films. The test monitor remained silent during each test. After the interpreter had selected a "match," he or she was asked to indicate which radiographic features had been most helpful in making the positive identification. All responses were recorded on a standardized form.

Results

The responses of each group of interpreters were evaluated with respect to: a) the percentage of correct matches for each test case, and b) the radiographic features cited as useful for making a positive identification.

Table 1 lists the percentage of correct responses for each group for each case. The high school students (Group I) had an overall accuracy rate of 84.3% compared to 91.5% for the medical students (Group II) and 94.7% for the radiology residents (Group III). The difference in the accuracy of responses of Group I and Group II (P = .34) and Group II and Group III (P = .58) were not statistically significant. The difference in the accuracy of Group I and Group III was statistically significant with a P value of 0.1 (P = .077).

The views of the skull (frontal and lateral), frontal cervical spine and female frontal chest were identified correctly most frequently, 98.0% overall. The radiograph of the lower leg proved most difficult with 58.0% correct responses among all three groups. Group III performed significantly better than Groups I and II with an overall accuracy

TABLE 1—*Accuracy of identification.*

	Group I		Group II		Group III		Total correct	
1. Frontal skull	14/14	100%	20/20	100%	18/19	95%	52/53	98%
2. Lateral skull	13/14	93%	20/20	100%	19/19	100%	52/53	98%
3. Frontal C-spine	13/14	93%	20/20	100%	19/19	100%	52/53	98%
4. Lateral skull	13/14	93%	20/20	100%	19/19	100%	52/53	98%
5. Pelvis (female)	10/14	71%	19/20	95%	18/19	95%	47/53	89%
6. Lateral foot	11/14	79%	19/20	95%	16/19	84%	46/53	87%
7. Frontal hand	11/14	79%	19/20	95%	19/19	100%	49/53	92%
8. Frontal lower leg	7/14	50%	9/20	45%	15/19	79%	31/53	58%
9. Frontal chest male	12/14	86%	18/20	90%	18/19	95%	48/53	91%
10. Frontal chest female	14/14	100%	19/20	95%	19/19	100%	52/53	98%
Total correct	$\frac{118}{140} = 84.3\%$		$\frac{183}{200} = 91.5\%$		$\frac{180}{190} = 94.7\%$		$\frac{481}{530} = 90.8\%$	

NOTE: Fractions = $\frac{\text{Correct Matches}}{\text{Total Responses}}$
% = Percentage of Correct Answers

of 79%. The remaining four test cases: pelvis, frontal hand, lateral foot and male frontal chest, were identified correctly with an accuracy ranging from 87.0 to 92.0%.

Table 2 summarizes the skeletal features used as points of comparison by each group in making a positive identification for each case. Only the most frequent responses are listed. Group I tended to rely on overall bony shape and dental fillings to identify the unknowns. Group II noted the unique configuration of paranasal sinuses, the sella turcica, degenerative changes and more focal bony characteristics as helpful in addition to dental fillings and overall bony shape. Group III showed more accurate description of bony findings and more confidently relied on small focal bony characteristics and differences in the trabecular pattern of bones as deciding features. Group III also more readily identified multiple points of comparison for each case than the other two groups.

Discussion

The results of this study support the need for trained interpreters in cases of difficult forensic identification. Predictably, the accuracy of each test group improved with its level of medical knowledge and interpretive experience. Although all three groups identified a majority of cases correctly, none were completely accurate. Group I with little or no medical, anatomic or radiologic training was able to correctly identify 84% of the

TABLE 2—*Radiographic features.*

Group I	Group II	Group III
Dental restorations	Shape of frontal sinus	Bone islands
Overall shape of individual bones:	Shape of sella turcica	Configuration of paranasal sinuses and mastoid air cells
—clavicle	Calvarial sutures	Degenerative osteophytes
—ribs	Calcification in maxillary sinus	Sesamoid bones
—spinous processes	Degenerative joint changes	Trabecular pattern
—sacrum	Soft tissue calcification	Granuloma
—calcaneus		Vascular grooves
Shape of heart		

cases. Group II with four years of medical training correctly identified 92% of the cases. Group III with specialized training in radiology improved to a 95% accuracy rate.

The accuracy of identification also varied with the body part evaluated. The views of the skull and cervical spine were more likely to be identified correctly. This confirms reports in the literature that note the value of skull and spine radiographs in identifying unknown remains primarily because of the abundance of bony landmarks [*1–3,5,8,10,13*]. The reliance on dental restorations is also well documented [*1–3,8–10,13*] and was noted by both inexperienced and experienced interpreters to provide a useful point of comparison. Participants from Groups II and III also frequently cited the configuration of the paranasal sinuses, the mastoid air cells and the sella turcica as distinguishing features. This has practical value in that the skull and spine are more likely to be preserved in cases of fire, severe decomposition or mutilation by small animals [*1,5,8,10,13,14*].

The frontal chest radiographs also were identified with a high degree of accuracy (male: 91%, female: 98%). Features mentioned as useful included the shape of the clavicles, ribs and spinous processes, the cardiomediastinal contour, a soft tissue calcification, pulmonary vascular markings and a scapular bone island. Martel et al. [*7*] emphasized the utility of a chest radiograph in forensic identification cases both because of the numerous bony landmarks and because of the likelihood that an individual would have had an antecedent chest radiograph. The usefulness of the chest radiograph may be limited by severe thoracic trauma or decomposition in actual forensic practice.

The frontal view of the lower leg was identified correctly the least. Group III performed with an accuracy of 79%, significantly better than the less experienced groups. Interpreters noted a lack of landmarks and relied predominately on overall bony shape and trabecular pattern. Features cited in the literature as important, such as evidence of previous trauma or surgery, normal anatomic variants and characteristic degenerative changes at the margins of joints, were notably absent in this test case as most of the adjacent joints were excluded [*8–10,13,14*]. The difficulty experienced by our participants with this case underscores the importance of the presence of abnormalities of anatomy as well as multiple bony landmarks as points of comparison in making an actual forensic identification.

The three groups of interpreters differed in their approaches to evaluating the test cases. Group I primarily considered overall bony shape and any obvious abnormalities, such as dental restorations. Group II also considered the shape of bones but focused more on comparing distinct anatomic areas and was more attentive to individual bony detail and degenerative change. Group III operated primarily on the principle of exclusion, then compared the remaining cases more closely, emphasizing fine bony detail and trabecular pattern.

This study differed from the actual practice of forensic radiographic identification in several ways which must be considered when evaluating the significance of the results. All of the test and comparison cases were obtained in standard radiographic projections which is attempted for post mortem radiographs but is not always accomplished in actual practice. Standard projections are especially difficult to reproduce in cases of fire, severe decomposition, or mutilation. Actual forensic radiographic identification also depends upon the presumed identity of the deceased which may or may not be accurate. The fact that all of our test cases had a definite answer increased the likelihood of a unreasoned correct guess and probably enhanced the apparent ability of the groups. The accuracy of the three test groups was not compared to a true "expert" group. We attempted to present cases with a range of difficulty using a nonrandom selection process for the case comparisons, which may have affected the results of one or more groups. Actual forensic identification is performed by pathologists, forensic anthropologists and radiologists. Only the latter training tract is evaluated in this study.

Conclusion

The radiographic identification of unknown human remains is based upon the knowledge that the human skeleton contains unique and characteristic bony detail that is preserved over time. The results of our study confirm the validity of identification of unknown remains by radiographic means when comparison radiographs are available, and support the need for trained interpreters in forensic identification.

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