TECHNICAL NOTE

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Pelvic Age Estimation Using Actual Specimens and Remote Images

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ABSTRACT: Age estimates of the auricular surface (sacro-iliac joint) of the ilium taken from bony specimens, 35 mm slides, and digital images were compared for 29 intact specimens from archaeological contexts. Results demonstrate that age estimates from all photographic and digital images may result in significantly differing estimates of age than those from bony specimens. Of the imaging techniques, 35 mm slides provided estimates most similar to those from bony specimens. Digital images provided age estimates that varied more from bony specimens. In general, photographic and digital images may offer researchers a way of documenting age information that would otherwise be unavailable or delayed. Yet, caution should be used when age estimates are derived solely from images rather than from bony specimens.

KEYWORDS: forensic science, forensic anthropology, age estimation, auricular surface, digital images

Remote age estimation has long been a concern for anthropologists whose work sites often are in distant localities, far away from urban centers and comparative materials, or in other countries that prohibit the removal of specimens for future consideration. Black and white or color photographs have been viable methods of image reproduction in the past, but recently new technologies of digital imaging and the rapid transfer of digital images over long distances have opened up new possibilities for remote age estimation. Each of the image reproduction techniques has relative merits that include quality of image, speed of image acquisition, speed of image processing, cost of image reproduction, and image duration and durability. Little is known, however, regarding the accuracy of the potential age estimates that might be derived from using the various image techniques compared with the age estimates derived from the actual specimen.

Accurate age estimates for humans can be obtained from the iliac surface of the sacro-iliac joint, also known as the auricular surface of the ilium (1–7). The auricular surface has topographic detail and bone texture that changes reliably with increasing age. The auricular surface method relies heavily on granularity of the surface and density of the bone as degeneration of the surface takes place (1,5). In this study, we report on the estimation of age from the auricular surface of the pelvis using the actual specimens and compare those age estimates to age estimates derived from a variety of remote images.

Methods

Twenty-nine intact adult auricular surfaces from archaeological contexts were examined for this study. Surfaces that were eroded or could not be interpreted were removed from the study sample prior to the interpretive stage. Age estimates were made from Ektachrome slide images of the specimens taken by a Pentax K-1000 manual camera using a 28 to 70 mm macro-zoom lens. Slide images were projected onto a screen and age estimates made from those projections. Digital images were also made from these slides using an Microtek Scan Maker 35t slide scanner at 4000 resolution. Digital photographs were taken with an Olympus D600-L camera at a resolution of 1200. Both sets of digital images were viewed on a 17 in. high-resolution computer monitor. The actual specimens were seriated and viewed macroscopically.

All photographic/digital images were made in the same manner. The actual specimen was placed on a light table covered with black velvet and photographs were obtained using tungsten (3200° Kelvin) artifical light. One of us (DLH) selected the specimens and produced the images; the other (KFR), performed age estimates independent of the selection process. Russell is one of the principal researchers of the auricular surface age method and has performed thousands of age estimates using the auricular surface. Each age estimate was made with a period of a month to two months in between to minimize bias from previous age estimates. In other words, a group of specimens was aged from the slide images, then from the digital images, then from the actual specimens. Two sets of pelves were used and analysis on the two sets was conducted a year apart. A third trial consisted of printing the digital camera images for the first set on a color inkjet printer one year after the initial monitor viewing.

We focused on two main issues: 1) Does any particular image process yields more accurate age estimates? 2) Are there predictable relationships between the age estimates derived from images and age estimates derived from the actual specimens? Age estimates were made from the images first in order to avoid bias generated by viewing the actual specimen.

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TABLE 1—*Comparison of age estimates obtained by the various methods.*

ID	Digital Monitor	Digital Print	Slide Projected	Bone	Bone-Slide	Bone-Digital Monitor	Bone-Digital Print
DR38-2	38	34	32	32	0	−6	−2
DR38-3			42				
DR38-4	39	40	44	24	−20	−15	−16
DR38-5-3	41	38	35	30	−5	−11	−8
CK9-5-2	42	44	25	30	5	−12	−14
CK9-5-5	40	37	45	40	−5	0	3
CK9-7-1	42	46	50	42	−8	0	−4
CK9-7-3	50	51	40	44	4	−6	−7
CK9-7-4	33	37	27	36	9	−3	−1
CK9-7-6	45	ADULT	24	41	17	−4	
CK9-7-7	36	36	31	42	11	6	6
CK9-7-8	35	38	33	35	2	0	−3
CK9-7-9	34	35	32	46	14	12	11
CK9-7-10	35	33	36	25	−11	−10	−8
CK9-7-11	25	24	20	<20			
CK9-7-12	27	23	<20	24		−3	1
CK225-1B	43		43	42	−1	−1	
CK225-1C	34		34	44	10	10	
CK225-1D	25		28	29	1	4	
CK225-1J	20		30	25	−5	5	
CK225-1K	36		48	46	−2	10	
CK225-1P	30–55		35	37	2		
CK225-1Q	33		39	37	−2	4	
CK225-1S	40		47	45	−2	5	
CK225-1Z	ADULT		40	47	7		
DR38-1	37		39	33	−6	−4	
DR38-7	23		27	23	−4	0	
DR38-14	42		44	38	−6	−4	

Results

For the purposes of this study, age estimates rendered on the actual bones are assumed to be the most accurate estimations of real chronological age. Each of the age estimates derived from remote images is therefore compared with the age estimates from actual bones. The least useful images were those obtained by using a slide scanner to produce digital images from Ektachrome slides. As a "second generation" image, those results are not surprising. The comparison of age estimates from Ektachrome slide and digital photograph images to the age estimates derived from actual bone specimens was variable (Table 1). Overall, 35 mm slides projected on a screen were more useful because of the better resolution and because they could be viewed closely without losing much resolution (Fig. 1). For the figures used in this article to illustrate the image differences, it is important to remember that they are reproduced here in black and white or grayscale; in our opinion color images are far superior for showing the necessary color and shadow used in age estimation. Digital images, although they had less resolution than the slides, have the advantage of almost simultaneous delivery and age estimation within a couple of hours (Fig. 2). The digital images made by viewing the specimens on the monitor yielded almost exactly the same age estimates as those made by viewing color printouts of the images a year later. It is our opinion that viewing the printouts is a better method than viewing the digital images on a monitor because it is easier to compare specimens with each other and with standards.

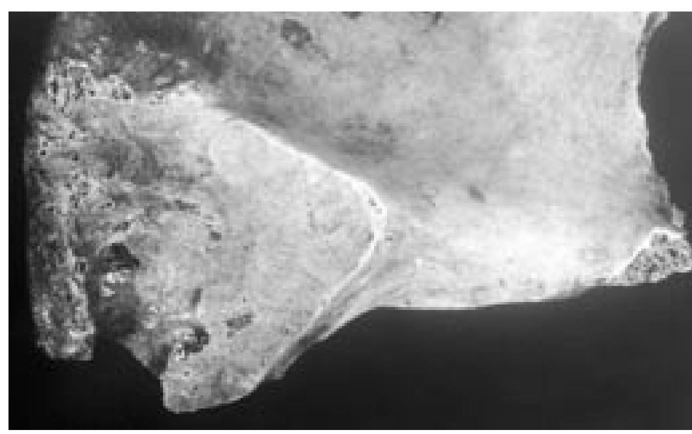

FIG. 1—*Example of a slide image transferred to black and white. The problems of transferring an image from one format to another are apparent in this image; the transfer from slide to black and white photograph has resulted in an image that is far less clear than the original. Although it would appear that the quality is better in the digital photograph presented in Fig. 2, the original slide was of far superior resolution.*

Comparison of the age estimates from the images with those from the actual specimens was also variable. Again, we have assumed that the best age estimates are made by examination of the actual specimen. Twenty-eight age estimates allowed comparisons between the actual bone and projected slide images (Table 1). Fourteen age estimates made from slides resulted in ages that were older than bone estimates and 13 in ages were younger than bone estimates. One estimate was identical for the bone specimen and the projected slide. The mean difference between age estimates made from the actual bone specimen and those made by projected slides is −0.15 (median = −1.5) years, with a range of 37 years. The central tendency measure, however, is misleading. Nine estimates (32%) made from viewing slides differed by more than

FIG. 2—*Example of a digital photograph printed in black and white.*

seven years from the estimate obtained from viewing the actual specimen (Table 1).

Twenty-five age estimates allowed comparisons between the actual bone and digital photograph images viewed on a computer monitor (Table 1). Twelve age estimates made from digital monitor photos resulted in ages that were older than the bone, nine in ages that were younger than the bone. Four estimates were identical between the bone specimen and the digital photograph. The mean difference between age estimates made from the actual bone specimen and those made by digital photographs viewed on the monitor is −0.71 (median = 0) years, with a range of 27 years. Seven estimates (28%) made from viewing slides differed by more than seven years from the estimate obtained from viewing the actual specimen (Table 1).

Fourteen digital photograph images were printed out on a color inkjet printer and used for comparison to the actual bone specimens (Table 1). Ten age estimates made from digital photos on the printer resulted in ages that were older than the bone, four in ages that were younger than the bone. The mean difference between age estimates made from the actual bone specimen and those made by digital photographs printed on a color inkjet printer is −3.23 (median = −3.0) years, with a range of 27 years. Five estimates (36%) made from photographs printed on a color inkjet printer were more than seven years from the estimate obtained from the actual specimen (Table 1).

A comparison between digital photographs viewed on the monitor and digital photographs printed on a color inkjet printer one year later helps to verify that it is the media and not the observer that influences age estimates over time. When comparing age estimates from digital images on the monitor to estimates from digital images printed on paper, no age estimates differed by more than 4 years, with a mean difference of 2.4 years.

Discussion

Our observations suggest: (a) When an image of the auricular surface is used for age estimation instead of the actual bone, slide images are more useful than digital images because they have higher resolution and because they can be projected and viewed closely without sacrificing resolution. The image method yielding the lowest mean difference between the age estimates obtained from the actual bone specimen and an image were for projected slides; (b) Although there are obvious advantages to using digital images, age estimates from digital photographs differed more dramatically from age estimates of actual bones. The image method yielding the greatest percentage of estimates that differed by greater than seven years from the age estimates obtained from the actual bone specimen was digital photographs printed on an inkjet printer (36%). However, all image production methods had at least 28% of the estimates differing by greater than seven years. (c) Mean ages suggest that the remote methods do not introduce directional bias into age estimates. However, the remote methods do show the tendency to overage the younger individuals and underage the older individuals compared with bone age.

More than 50% of the age estimates derived from images fell within seven years older or younger than the age estimates obtained from the actual bone specimen. Conversely, between 28 and 36% were greater than eight years older or younger than the estimates made from the actual bone specimen, many as much as 15 or 20 years older or younger. Bedford, et al. (1989) photographed over 50 auricular surfaces to establish the set of photographs with which to teach the auricular surface aging technique. They found it necessary to photograph several different surfaces in each age lustrum because often the photograph simply did not "look" its age, even though gross inspection of the bone was consistent with known age of the specimen.

These results suggest that one should employ caution when generating age estimates from photographic or digital images of the auricular surface. Similar caution should probably be employed with the pubic symphysis as the topography of the face and the degenerative changes important for age estimates are similar to the auricular surface. Photographic standards for these methods have been carefully selected because they "look" their age. This may not always be the case. Sometimes the experienced observer can detect bone texture, pathology, or unusual aging patterns that can help indicate age from the real bone, even when these indicators are not evident in a photographic or digital image. However, necessity sometimes dictates that an image of the actual specimen must be employed to derive an age estimate. For instance, distance from an experienced auricular surface age estimator or the need for a very fast age estimate in forensic contexts may require the use of images rather than actual specimens. Our study provides guidelines for obtaining those images and interpreting pelvic age estimates derived from those images.

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