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Techniques for siding manual phalanges

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ABSTRACT

Identifying the anatomical origin of skeletal elements is a basic and important part of a forensic anthropological investigation, but techniques for determining the side and ray of the phalanges are conspicuously scarce in the physical anthropology literature. Features of particular phalanges are important to aspects of archaeological and paleoanthropological studies, as well as for identification and trauma analysis in forensic cases. Correct siding of phalanges may therefore be quite critical in certain contexts. This study evaluates several siding techniques previously developed and/or described in a recent study by Case and Heilman (2000) [1]. Unlike in their study where observers were provided all phalange positional information except for side, observations in this study were undertaken with no positional information provided thus making the examinations more similar to those performed in a forensic context. Tests of phalange siding techniques were carried out on two skeletal samples: the Terry Collection at the Smithsonian's National Museum of Natural History where the ray and side of phalanges are documented and phalange collections are often complete, and the Bass Collection at the University of Tennessee where phalange positional information is undocumented and where phalange collections are seldom complete. The features described by Case and Heilman were found to work quite well. In the documented (Terry) sample, there was a high rate of correct siding, up to 100% for several phalanges. In the undocumented (Bass) sample, the features could be used to side the phalanges to a reasonable degree of certainty, and certainty increased when both sides of a particular phalange were present. Finally, several other useful siding and ray identification features were identified.

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1. Introduction

Identifying the precise anatomical origin of skeletal elements is a basic and important part of a forensic anthropological investigation, but methods for determining the side and ray of the hand phalanges are conspicuously scarce in the physical anthropology literature. Although important to aspects of archaeological and paleoanthropological studies, features of particular phalanges may be useful in identification and trauma analysis in forensic cases as well, and correct siding may therefore be quite critical. Recently, Case and Heilman [1] published several new techniques (and summarized previously described ones) for determining the side of manual phalanges, and here, several other potentially useful techniques are reported.

The purpose of this paper is to evaluate the techniques in a scenario more representative of a forensic context. The present study tests the application of the techniques reported by Case and Heilman [1] using two skeletal samples; one where the ray and side of phalanges are documented, and one where this information is undocumented and where phalange collections are seldom complete. Furthermore, in their blind study, Case and Heilman [1] provide the examining scientist with the ray and phalanx type (e.g., proximal phalanx from the first ray), and each bone was examined individually to determine side only. In contrast, in this study, no positional information was provided to the examiner, and all phalanges from an individual were evaluated together so that all available information could be used to estimate both the ray and side of origin for each phalanx, similar to the approach one might use in a forensic examination.

2. Materials and methods

The Terry Collection at the Smithsonian Institution's National Museum of Natural History contains well-documented early 20th century skeletons obtained following medical school dissection. The remains were processed using hot water maceration and efforts were made to keep track of the anatomical position of all skeletal elements, including phalanges. This is the same collection used in Case and Heilman's study [1] and was used here to re-evaluate and validate the siding techniques developed by the authors, as well as to test several additional techniques developed for the current study.

The University of Tennessee houses the William M. Bass Donated Skeletal Collection, a collection of modern skeletal remains which are accessioned following decomposition at the institution's Anthropological Research Facility (ARF). The remains are recovered from the ARF, cleaned of remaining soft tissue and debris using hot water and cleanser maceration, and inventoried prior to placement into the skeletal collection. No efforts are made, however, to monitor or document the ray or side from which manual or pedal phalanges originated, and inventory

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protocol simply requires the documentation of the total number of hand and foot phalanges present. Moreover, phalanx collections from the ARF are often incomplete. The Bass Collection thus resembles what may be recovered in a forensic context, and presents the same challenges with regard to manual phalange identification. Indeed, this skeletal sample was selected for this study because of its similarity to forensic samples where recoveries may be incomplete, taphonomic agents have played a role, and "answers" are not known. The purpose of using this collection for a portion of the study is to (albeit rather subjectively) evaluate the ease of use and reliability of locating and identifying the described features under forensic context-like conditions.

In order to validate the siding techniques on known-side specimens (as well as evaluate the proficiency of the author at applying them), a sample of 31 sets of phalanges were examined from the Terry Collection. Side markings were obscured by a second researcher, and side was estimated for each phalange present after assessing the ray (1–5) and position (proximal, intermediate or distal) of origin. In ten of the 31 cases, distal phalanges were labeled as to side on the proximal articular surface which is a useful area for estimating side. Due to the inability to obscure the side information in a way that still allowed a meaningful examination, side was not attempted for those elements of those specimens. Proximal and intermediate phalanges from these cases were still evaluated.

The phalanges of 166 individuals were examined from the Bass Collection. No bones are labeled as to side and therefore no obscuring method was required. All manual phalanges were first separated from the other bones of the hands and feet, and then side was estimated after assessing the ray and position of origin.

Ray and side were estimated based on the descriptions outlined by Case and Heilman [1], descriptions published by Susman [2], Ricklan [3] and Scheuer and Black [4], and new techniques developed during observations here. For ray estimation, relative length patterns are the most frequently published and apparently the most generally accepted method, and can be summarized as follows:

For proximal phalanges (PP): PP3 > PP4 ≥ PP2 > PP5 > PP1.
For intermediate phalanges (IP): IP3 > IP4 > IP2 > IP5.
For distal phalanges (DP): DP1 > DP3 ≥ DP4 > DP2 > DP5.

(DP2-5 can also be seriated by robusticity, where DP3 > DP2 > DP4 > DP5).

In addition to the morphological and metric characteristics of the phalanges, any other ray or siding information available was used in this assessment. Additional siding information included features such as the appearance of only one hand being present/recovered, bone pathology or trauma, and differential discoloration resulting from decomposition, staining or bleaching.

For the Terry Collection specimens, side was recorded and then compared to documented side information. A similar assessment of the Bass Collection was not possible given the lack of side documentation. Thus, rather than comparing estimates to a documented known, the confidence in whether the side or ray was correctly assessed based on all of the available information was recorded. All assessments were performed by the author, and confidence in the side and ray of each individual phalanx was recorded as:

0 = unsure/cannot tell; 1 = somewhat sure; 2 = reasonably sure.

A "0" indicated that the characteristics were not obvious and/or the techniques were inapplicable and assessments were no better than guessing, a "1" indicated that characteristics appeared to suggest a particular side or ray but it was not entirely clear, and a "2" indicated that the bone fit neatly into the descriptions and the bone's side or ray was assessed with reasonable confidence based on the descriptions.

3. Results

3.1. Proposed improvements

After studying phalanges from the Terry and Bass collections, additional siding and ray identification features that appeared helpful were described. Table 1 summarizes siding features outlined by Case and Heilman [1], including descriptions from Ricklan [3], as well as additional siding features identified during the course of this study. Additional features as well as several other observations of note are mentioned in more detail below and illustrated in Fig. 1 (illustrations for the techniques developed in previous studies can be found within those papers).

When recoveries were incomplete, relative lengths could not always be relied upon to estimate ray. In many cases, however, it may be possible to estimate the ray based on some of the siding characteristics identified by Case and Heilman [1]. For instance, PP4 and PP2 are often nearly the same length, but they can be distinguished based on their relative robusticities with PP2 having a more robust base than PP4. As Case and Heilman [1] as well as Susman [2] point out, however, it is not just that PP2 is more robust; the robusticity is asymmetric, which helps in estimating the side. In a case where only PP2 or PP4 is present, one can examine the base for both robusticity and asymmetry and conclude not only whether it is PP2 or PP4, but also from which side it originated (Fig. 1a).

A similar finding was noted for IPs (Fig. 1b). Again, IPs can normally be distinguished based on their relative lengths if they are all present, but this is not always the case. As Case and Heilman [1] note, IP2 and IP3 have asymmetric bases which are useful in estimating side, but this feature can also be used to distinguish them from IP4 which has a relatively symmetric base. It should be noted that IP4 shows some similar asymmetry, which (if present) can be used to side it in the same way as IP2 and IP3, but makes it more difficult to distinguish from IP3, especially when they are not both present. IP2 also tends to have a more flared base than IP3 or IP4, which tend to be relatively more slender.

Case and Heilman [1] describe the tubercles on the palmar surface of PP4 as having different heights. Indeed, sometimes one was observed to be notably higher than the other, but it was also noted that the higher of the tubercles was usually significantly more angular. Sometimes the tubercles were roughly the same height, but whether the same or different in height, the more angular tubercle was a better indicator of side. When viewed from the proximal articular facet with the palmar surface up, the more angular of the tubercles is on the side that the bone is from (Fig. 1c).

Although Case and Heilman [1] identify the extension of the superior-distal facet of PP5 as the more reliable siding trait, their second-rated characteristic (the distal most point of the distal articular region when viewed from the dorsal side) was found to be easier to see and more confidently applied (Fig. 1d). When viewed from the dorsal surface, the most distally projecting side of the distal end is opposite the side the bone is from. The slanted appearance it gives to the distal region also makes it easy to distinguish from other PPs.

The technique Case and Heilman [1] describe for siding PP1 was occasionally found to be challenging to apply. In several cases, proximal facets of PP1 were observed that were basically flat, rendering both of their techniques inapplicable. Development of a technique that could be applied when observing from the direction of the proximal end and did not rely on projection of portions of the proximal surface was thus attempted. When viewed from the proximal end with the dorsal side up, the articular facet almost, but not completely, encompasses the proximal end; the articular region extends all the way to one side of the proximal end but not the other. The side of the proximal base with the most non-articulating surface is the side the bone is from (Fig. 1e).

Similarly to Case and Heilman [1] and others [2–4], the distal phalanges were found to be the most challenging to side. Very few cases were encountered where the two proximal facets could be clearly distinguished, let alone assessed for relative size. Occasionally, this was due to either osteoarthritic lipping or adhering soft tissue, but more often it was just that it was simply difficult to identify the delineation between the two facets.

DPs had the lowest recovery rate (on average, only half were recovered in the Bass Collection) which made ray identification difficult since the relative length and robusticity techniques could not often be applied. While DP1 was always confidently identified and sided, and DP5 could often be identified, DP2-DP4 often presented difficulties. Since the siding technique is similar for those elements, however, the side was often more easily assessed than the ray.

3.2. Skeletal assessments

For the Terry Collection sample using the techniques outlined in Table 1, 100% siding accuracy was achieved on the following