CHAPTER 1

INTRODUCTION

1.1 General introduction

Anatomy textbooks provide very little information regarding descriptions of individual bones of the human hand. The metacarpals are more readily described than the phalanges. This is because metacarpals are asymmetrical in their morphology which allows them to be easily distinguished from each other. The identification of phalanges, on the other hand, poses a problem in that they are symmetrical in their morphology which makes it almost impossible not only to distinguish them from each other, but also to side them. A further problem arises when looking at the morphology of the three phalangeal series of hand bones. Proximal and middle phalanges have similar morphological features while distal phalangeal bones differ from those of the proximal and middle rows in that they are not only relatively smaller, but the distal end has a non-articulating surface (Romanes 1991, Bass 1995, Moore & Dalley 2006).

The availability of human hands from skeletal collections and cadavers obtained from dissections has provided the opportunity for detailed morphological analyses of these hands. This information may complement analyses of skeletal elements from other parts of the human body used in various anthropological and forensic cases. It may also allow for an indirect assessment of hand function (Ricklan 1987). Analyzing form and structure of human hand bones from juveniles, has led Scheuer and Elkington (1993) to suggest that it is possible to derive distinguishing features which could be used not only to identify, but also to side individual hand bones. No studies, providing such detailed descriptions of the morphology of hand bones of the South African population, have been carried out.

The asymmetry of human hand morphology and human variation in general, is derived from various sources, including biological inheritance. One of the important aspects of physical anthropology is to identify and assess various aspects of human variation which is governed by mutations, genetic drift, natural selection, social and cultural environment (Nishihara *et al*. 2003, Singh 1959). During this assessment, attempts are made to discover factors that cause similarities as well as differences. Such factors may arise from human evolution, impact of the environment, sociocultural variation, wars and mass disasters.

Skeletons or skeletal remains are often discovered commingled. This makes it difficult to identify victims, not to mention putting parts of the skeleton together based on age, sex, population affinity and stature (Krogman & İşcan 1986). Forensic anthropology, which is a speciality within forensic medicine and a branch of physical anthropology, involves the assessment of such human skeletonized remains and their environments (Krogman & İşcan 1986). To the qualified specialist in the area of identifying human skeletal remains, a thorough knowledge on various fields such as comparative osteology, human osteology, craniometry, osteometry and racial morphology, is crucial in order to carry out these assessments (Krogman & İşcan 1986). The assessment of stature from skeletal remains contributes greatly to the identification process. Long bones are commonly used to determine stature (Black 1978, Dayal 2002, De Mendonca 2000).

The high homicide rate in South Africa has resulted in considerable growth in the field of forensic science and forensic anthropology (Steyn & İşcan 1997). Forensic cases present with bodies in an advanced or complete stage of decomposition where only the skeleton is discernable. In these forensic cases, as much information as can be gathered is required in order to identify individuals. The surge in research in this country is thus devoted primarily to devising standards that are specific for its population. This is because available skeletal forensic identification standards are based on North American and European samples which cannot be applied to South African studies or any other population (Steyn & İşcan 1999).

The aim behind these projects is to establish sufficient data that would assist in medico-legal investigations in South Africa (Franklin *et al*. 2006). Alongside the establishment of stature estimation methods for the South African population, a steady increase in research on the determination of sex for this population group occurred. While various aspects of the human skeleton have been used to determine sex for the South African population (e.g., De Villiers 1968, Kieser *et al*. 1992, Loth & Henneberg 1996, Steyn & İşcan 1997, 1998, 1999, Asala 2001, Asala 2002, Bidmos & Asala 2003, Bidmos & Dayal 2003, 2004, Asala *et al*. 2004, Bidmos & Asala 2004, Dayal & Bidmos 2005, Barrier 2007, Barrier & L'Abbé 2008, Franklin *et al*. 2006, 2008, Patriquin *et al*. 2003, 2005), no studies on the use of hands to determine the sex or height of an unknown individual has been done. Thus, no discriminant function or regression formulae using the hand bones are available for this population group.

Exploration of the hands in sexually dimorphic studies, has received very little attention in the past. This has now changed as current research has shown that the epiphyseal regions of long bones are more susceptible to damage than the smaller long bones of the hands and feet which are often found to be complete. This motivates for their use in establishing differences between males and females (Scheuer & Elkington 1993, Lazenby 1994, Falsetti 1995, Smith 1996). The use of the skeletal elements of the hands as an aid in identifying the sex of an unknown individual in South Africa is lacking. Thus, no discriminant function formulae for the hand bones have been devised for this population group.

1.2 Aims

The aim of this investigation is to analyse the metacarpals and phalanges of the human hand. In this analysis, the following aspects will be addressed:

A. The development of methods and descriptions that would enable researchers to identify these bones as far as their side and number are concerned.

B. To determine the length of a specific long bone by the length of a specific hand bone. The value obtained can then be inserted into regression formulae devised by Lundy and Feldesman (1987) and Dayal *et al*. (2008) for final estimation of stature.

C. Various measurements will be taken in order to assess sex differences using metacarpals and phalanges. From these measurements, discriminant function formulae will be devised.

1.3 Hypotheses

The information and data obtained from aim A above, will then be used to verify or nullify the following hypotheses:

1. The lengths of the metacarpals and phalanges of the human hand can be used to estimate the length of a long bone which in turn can be used to determine stature of an unknown individual, through the use of regression equations. This hypothesis will be accepted if the standard errors of the equations are of similar magnitude than those obtained for other long bones of the body.
2. The dimensions of the metacarpals and phalanges of the human hand can be used to determine the sex of an unknown individual through the use of discriminant function formulae. This hypothesis will be accepted if more than 80% of the individuals in the sample are correctly assigned.

CHAPTER 2

LITERATURE REVIEW - MORPHOLOGY OF THE HAND BONES

2.1 Introduction and general anatomical descriptions

The internal skeleton serves as a basic framework for the human body. Within this framework are a number of individual bones including the skeletal elements of the hand. Modern humans use their hands primarily for object manipulation with each digit designed to carry out a particular function (Tocheri *et al*. 2003). Based on its function, each digit displays variation in its structure. One of the important aspects of physical anthropology is to identify and assess not only human differences, but also those variations that may exist in hand morphology. During this assessment, there are attempts to discover factors that would cause similarities as well as differences in morphological structure. Such factors may arise from human evolution (Aiello 1992), impact of the environment and sociocultural variation (Nishihara *et al*. 2003).

Human osteology, which is the study of the human skeletal system, is one discipline that is used to gain this knowledge. Textbooks on human osteology have provided brief descriptions on various parts of the skeleton. To the qualified specialist in the field of identifying human skeletal remains, a thorough knowledge on various fields are crucial, including knowledge of human osteology, osteometry and morphology (İşcan 2000, 2004).

It has been suggested that the shape of a bone is determined largely by intrinsic factors with extrinsic factors playing a minor role. Intrinsic factors are primarily involved in molding a bone to its unique shape which would firstly, reflect its ability to perform certain functions and secondly, provide it with the strength to resist certain stresses. Extrinsic factors such as pressure of adjacent structures and the force of pull that a muscle exerts on a bone, brings about a secondary molding of the bone. This is then followed by secondary markings which can be identified on the bone. An example of this occurs when a muscle attaches to a relatively large surface area and it results in a smooth region of the bone. Secondary markings may also form as prominences on a bone. In such cases the terms tuberosity, protuberance and tubercle are used. If the bone markings are more linear, then the terms used to describe them would be a ridge, crest or line (Leeson & Leeson 1989). Thus, a detailed description of the final shape and morphology of adult hand bones is important in order to relate structure to function and perhaps even to the evolutionary history of this part of the skeleton.

Osteology of the hand, however, has been confined or limited to a single paragraph in major anatomy textbooks (Bass 1995, Romanes 1991). These textbooks do not provide detailed descriptions on identification of hand bones. There is little information regarding variations of individual bones of the human hand, except for the occasional reference to the presence or absence of a medial facet on either the third metacarpal base or lateral side of the fourth metacarpal base (Bass 1995, Romanes 1991). Information regarding side differences is also lacking in these sources. Thus, no conclusive method has been described in anatomy textbooks to identify the various metacarpals and phalanges of the human adult hand as far as their side and number is concerned.

To identify, distinguish and side bones of the human hand, especially the phalanges which occur in three series, is an exceptionally difficult task. This may explain why very few studies have been conducted on the skeletal elements of the hand for forensic anthropological purposes. It is clear from the literature, that identification and variation of individual adult hand bones, as well as variations in side and number, has received the least attention. Yet, the hand is perhaps the most important part of the body that opens the brain to the world and vice versa, by its assessment of the three dimensional environment.

From a functional perspective, the human hand has been adapted in such a way so as to allow an individual to manipulate its environment. Some of these functional movements include grasping, squeezing and pinching. The muscles which carry out these movements must exert a certain force on the bones, resulting in morphological changes which should be evident visually.

Ossification of metacarpals takes place from two centers, one for the body and one for the distal extremity. The first metacarpal differs from adjacent bones in the series in that it has an ossification center for the body and one for the base rather than for the distal extremity.

This has led anatomists to consider the thumb as being made up of three rather than of two phalanges and a metacarpal. The phalanges, on the other hand, are each ossified from two centers, one for the body and one for the proximal extremity (Williams *et al*. 1989). The ossification process in hands is often accompanied by notches seen at the radial and ulnar margins of non-epiphyseal ends of the bones (Levine 1972).

To carry out a study on hands, whether it is metrical or non-metrical in nature requires a reliable sample. As early as 1931, Ashley-Montagu realised the importance of carrying out skeletal measurements on hands obtained from a reliable sample. In order to achieve this, he emphasized that there should be full control over the manner in which the sample is collected, cleaned and labelled.

2.2 Literature review

Before providing reviews on individual bones of the hand, it may be worthwhile mentioning the use of different anatomical terms for hand bones in textbooks. In general, anatomical terminologies have been standardised worldwide to maintain consistency in textbooks.Terms that are used to describe relationships of certain parts of the human body in the anatomical position, are usually arranged in pairs. An example of this includes the terms superior and inferior. Sometimes a combination of terms may relate to the intermediate positional arrangement of structures and these may include words such as inferomedial or superolateral. Terms such as proximal and distal indicate direction or position (Moore & Agur 2002).

Terminologies of orientation in the hand, for example, may differ from one author to the next. Examples of this include the following: palmar (Williams *et al.* 1989, Romanes 1991) instead of volar (Scheuer & Black 2000), anterior (Moore & Dalley 2006) instead of palmar (Gray 1959, Williams *et al.* 1989), radial and ulnar (Hollinshead & Jenkins 1981, Williams *et al.* 1989) instead of lateral and medial (Moore & Dalley 1989) and superior (Gray 1959) instead of proximal (Romanes 1991). In some instances, terminologies used to describe bony landmarks may not always be specific. For example, reference may be made to the presence of a tubercle on the shaft without clarifying whether it is laterally or medially positioned at either the proximal or distal end of the bone (Romanes 1991). While there appears to be numerous terms used by various authors, this does not affect the description of the individual bones of the hand.

2.2.1 Metacarpals (Figure 2.1)

Naming of individual metacarpal bones differs slightly in the various textbooks. Generally, the five metacarpals (Figure 2.1) are commonly written down using Roman numerals, namely, metacarpal I, II, III, IV and V. Some anatomical textbooks simplify the naming system even further. For example, a textbook may refer to the first, second, third, fourth and fifth metacarpals (Williams *et al.* 1989). The numerous ways of naming metacarpals does not confuse the reader from knowing which bone is being described.

To date, the most comprehensive description of the human hand is that of the developmental juvenile individual, where detailed descriptions of each metacarpal are given (Scheuer & Black 2000). While this detail is lacking in metacarpal descriptions of the human adult hand, numerous anatomy textbooks have attempted to describe or at least mention, certain visible landmarks on these bones. On the other hand, descriptions on metacarpals are given in slightly greater depth than for the phalanges (Bass 1995, Romanes 1991). This is because each metacarpal has distinctly visible features, especially at the base, which allows them to be easily identified. Williams *et al.* (1989), in their 37th edition of Gray's Anatomy, provides detailed descriptions of the metacarpals and phalanges. The latest issue of Gray's Anatomy (2005), as is the case with many current anatomical texts (Moore & Dalley 2006), is more clinically based resulting in loss of detailed anatomical descriptions.

Where hand bones are described, their orientation is crucial. When teaching anatomy of the upper limb region, which includes the hands, the body is generally placed in the anatomical position. In other words, the palm of the hand faces anteriorly with the dorsal aspect directed posteriorly. In this way, the thumb is described as the most lateral digit and the little finger as the most medial digit (Gray 1959, Williams *et al*. 1989, Scheuer & Black 2000). These terms of orientation are also applicable to anthropological and forensic cases where individual hand bones may be recovered amongst the rest of the skeletal elements of an unknown individual.

Textbooks generally describe each metacarpal as having a head, shaft, and base (Gray 1959, Williams *et al*. 1989, Romanes 1991). The presence of a neck on metacarpals may sometimes also be mentioned (Marrero *et al*. 2007). Usage of common names may be used to refer to a region of a bone. For example, Gray (1959) refers to the metacarpal head as a knuckle, which contributes to the formation of the metacarpophalangeal joint. Metacarpals two to four, sometimes also referred to as the medial four metacarpal bones (Williams *et al*. 1989), is often described as running parallel to each other. These four medial bones are described as diverging from each other in a proximal distal direction when the fingers are abducted (Williams *et al*. 1989).

Metacarpals may be discussed in conjunction with the proximal phalanges and distal row of carpal bones because of their close association with them. For example, the proximal end of the first metacarpal, which is the most mobile of the metacarpal series of bones, articulates with the trapezium, the second with the trapezium and trapezoid, the third with the capitate, and the fourth and fifth with the hamate (Williams *et al.* 1989, Moore & Dalley 2006, Marrero *et al*. 2007). The head of each metacarpal in turn ariculates with the proximal phalanx that corresponds to each digit (Moore & Dalley 2006).

A survey of the literature indicates that metacarpals are often described in terms of their function. One such study is that carried out by Tubiana (1981), where the position of each digit is related to a specific function. For example, the position of the thumb allows it greater mobility in terms of opposition when compared to adjacent metacarpals. The index finger is listed by Tubiana (1981) as second in priority because of its close proximity to the thumb. Its function is the inherent ability to carry out abduction movements efficiently as is needed during pinch and key grip movements. In such activities, the function of the index finger is not isolated from that of the thumb. Tubiana (1981) relates the strength that this digit has in flexion, precision and power grip movements, to its relative length. Tubiana also describes the function of the ring finger in terms of its distance from the thumb. The strength of this digit is observed during flexion movements, however, the strength of flexion is far less when compared to that of the index and middle finger. The position of the little finger with respect to the thumb is given the least priority (Tubiana 1981).

The advantage that the little finger has over the thumb, with respect to its position in the hand, is its greater range of abduction which is far more than what can be achieved by any of the adjacent digits in the same series. In terms of function, this advantage enables an individual to hold objects firmly against the hypothenar eminence with a certain force. This force is also brought about by the muscles associated with the little finger. The force exerted by these muscles may leave an impression on the bone which may be visible to the naked eye. Such impressions on the bone should assist not only in identifying but also in siding a bone (Tubiana 1981). The location of the little finger thus provides a point of stability, which is of functional importance. This stability, however, may be at the expense of mobility, a function preserved for the thumb.

From this perspective, suggestions have been put forward that many of the noted morphological features of the human hand can be traced back to evolutionary development, and in particular to the amount of stress placed on it (Susman & Creel 1979, Marzke 1983, Marzke & Marzke 1987). The base of the first metacarpal and its contribution to the carpo-metacarpal joint, is designed primarily to allow for increased range of thumb movement (Marzke 1983). The second metacarpal is thought to provide various patterns of evolutionary changes (Lazenby 1998). The presence of a styloid process on the third metacarpal (Williams *et al*. 1989) may provide for stability of this bone in the palm, and its absence may be linked to ligamentous changes which are crucial for stability at the wrist joint (Marzke 1983, 1992a). It would seem that the human hand has undergone a prolonged process of evolutionary change. During this period, the individual skeletal elements of the hand were remodelled, adapting itself for function.

2.2.2 Phalanges (Figures 2.2 to 2.4)

Unlike the metacarpals, which are allocated roman numerals or in some cases called metacarpals 1 to 5 in order to identify them, the phalanges are not numbered at all. Instead, they are merely referred to as the proximal, middle and distal phalanges belonging to the thumb, index, middle, ring and little finger respectively (Matshes *et al*. 2005, El-Najjar & Mc Williams 1978). This form of identifying individual phalanges makes it easy to associate them with a particular finger.

The phalanges are sometimes referred to as miniature long bones with a broad base proximally and a head distally (Romanes 1991). This description does not differentiate the proximal, middle and distal phalanges from each other and cannot be used to identify nor side one series of phalanges from the other. The phalanges of the thumb are basically described as being the shortest and broadest bones when compared to the corresponding bones of adjacent fingers (Romanes 1991). Furthermore, in order to differentiate phalanges of the various digits in one hand, those of the middle finger are regarded as the longest, the little finger as the shortest while those of the ring and index fingers are considered to be of relatively equal length (Romanes 1991).

Descriptions of the phalanges, when compared to those of the metacarpals, are even fewer (Gray 1959, Tubiana 1981, Romanes 1991, Scheuer & Black 2000). The group of phalanges that is perhaps the most difficult to distinguish are the distal bones in this series. Very little, if any, morphological traits are given for the distal phalanges. Some authors have attempted siding techniques by carrying out a blind test using hand bones supplied by anatomical companies and refining the descriptions by comparing it to those of a skeletal collection. Once landmarks were identified by these authors, the bones were then field tested on protohistoric samples (Case & Heilman 2006). In this way, Case and Heilman (2006) developed a method for siding phalanges of the human hand. These authors used some of the features devised by Ricklan (1987, 1988) on hominids as no standardized technique existed for phalanges of the human hand. Case and Heilman's technique for siding the phalanges is seen in Tables 2.1 and 2.2 and illustrated in Figures 2.5 and 2.6.

The thumb, which presents with only two phalanges, may pose less of an identification problem. This is because the distal phalanx of the thumb is relatively bigger in size than the corresponding bone of adjacent fingers in the same hand. Other than this form of identification, the literature does not provide specific morphological traits to identify or side phalanges of the thumb. The first metacarpal may actually be a proximal phalanx as epiphyseal growth is present at the proximal end, similar to that seen in proximal phalanges of adjacent fingers. Attempts have been made by various authors to study the reduction in number of the phalanges in animals with very little success in order to explain the reduced number of phalanges in the first digit (Galis *et al.* 2001).

The few descriptions on phalanges make positive identification of an individual phalanx difficult. Even in studies on the juvenile hand, observations of the phalanges have been restricted to general morphological descriptions of the proximal, middle and distal phalanx as this presents with very few problems (Scheuer & Black 2000). Ligaments and muscles which attach to various bony sites on the phalanges may also be listed with descriptions of these bones In other words, there should be an imprint left on each hand bone as evidence of soft tissue forces placed on a specific area of these bones. The attachment sites of the dorsal and palmar interossei on the phalanges differ, thus creating different forces on these bones. It is assumed that various forces of pull on each phalanx will, over time, present with a bony landmark that can be used not only to identify but also to side the proximal phalanges of the various digits (Scheuer & Black 2000).

Some descriptions of the shaft are given in terms of their curvatures. For example, the shaft of proximal phalanges are said to have a convex dorsal and concave palmar surface. The relative length of a hand bone may also be used for identification purposes. An example of this is the proximal phalanx of the thumb, which is said to be the shortest bone while the middle finger is considered as the longest bone. The proximal phalanges of the remaining digits are then listed in order of increasing length, namely, the fifth, second and fourth digit (Scheuer & Black 2000).

The shape of the proximal phalangeal base is said to be dictated by the shape of the metacarpal bone which it articulates with. The shape of a bone is often used in joint classification systems. For example, the metacarpophalangeal joint is classified either as an ellipsoidal or bicondylar joint (Scheuer & Black 2000). The articular surface of the proximal phalangeal base is considered to have a single concave oval facet which is relatively longer in width than in a dorsopalmar aspect (Scheuer & Black 2000). The heads of the proximal phalanges are described as being bicondylar with the medial and lateral condyles varying in relative size for each proximal phalanx (Scheuer & Black 2000). For example, the medial condyle is said to be larger than the lateral one in proximal phalanges of second and third digits while the lateral condyle is seen to be relatively larger in proximal phalanges of digits one, four and five respectively (Scheuer & Black 2000). Often the condyles are simply described as being small with no reference to their difference in size (Bass 1995).

The only descriptions provided for the middle phalanges is that they are the second row of bones in the phalangeal series with a head, base and shaft (Bass 1995). Distal phalanges have previously been referred to as ungual phalanges because of their claw-like appearance at the distal end. These bones are not described in detail in any anatomy textbook, except to state that it also has a base, shaft and head. What is described is the triangular shape of this bone with a wide base and tapered distal end. The distal phalanx of the thumb can be distinguished from those of adjacent digits based on relative size, as it is the longest and most robust bone in this series. It is also the only row of phalanges that has a non-articular distal extremity (Scheuer & Black 2000).

The literature records various degrees of robusticity for the distal phalanges of digits two to five (Scheuer & Black 2000). In order of decreased robusticity they are listed as the first, third, second, fourth and fifth distal phalanx (Scheuer & Black 2000). The base (proximal end) of a distal phalanx articulates with the head (distal end) of a middle phalanx in the case of digits two to five, forming the distal interphalangeal joint. In the thumb, the distal phalanx articulates with the distal end of a proximal phalanx forming an interphalangeal joint (Scheuer & Black 2000).

Two articular facets have been recorded on the articular surface of the distal phalangeal base in the juvenile infant (Scheuer & Black 2000). The dorsal surface is smooth except for an area at the proximal end of the dorsal surface which serves for attachment of the tendon of extensor pollicis longus in the thumb and the tendons of extensor digitorum in the adjacent digits (Scheuer & Black 2000). At the distal end of the dorsal surface, the distal phalanx is smooth. This is part of the bone deep to the fingernail. The palmar surface, in contrast, is rough and flattened at the proximal end owing to the attachment of soft tissue structures (Gray 1959, Scheuer & Black 2000).

Figure 2.1: Dorsal (A) and palmar (B) view of metacarpals (MC) 1 to 5 of the right (R) hand.

Figure 2.2: Dorsal (A) and palmar (B) view of proximal phalanges (PP) 1 to 5 of the right (R) hand.

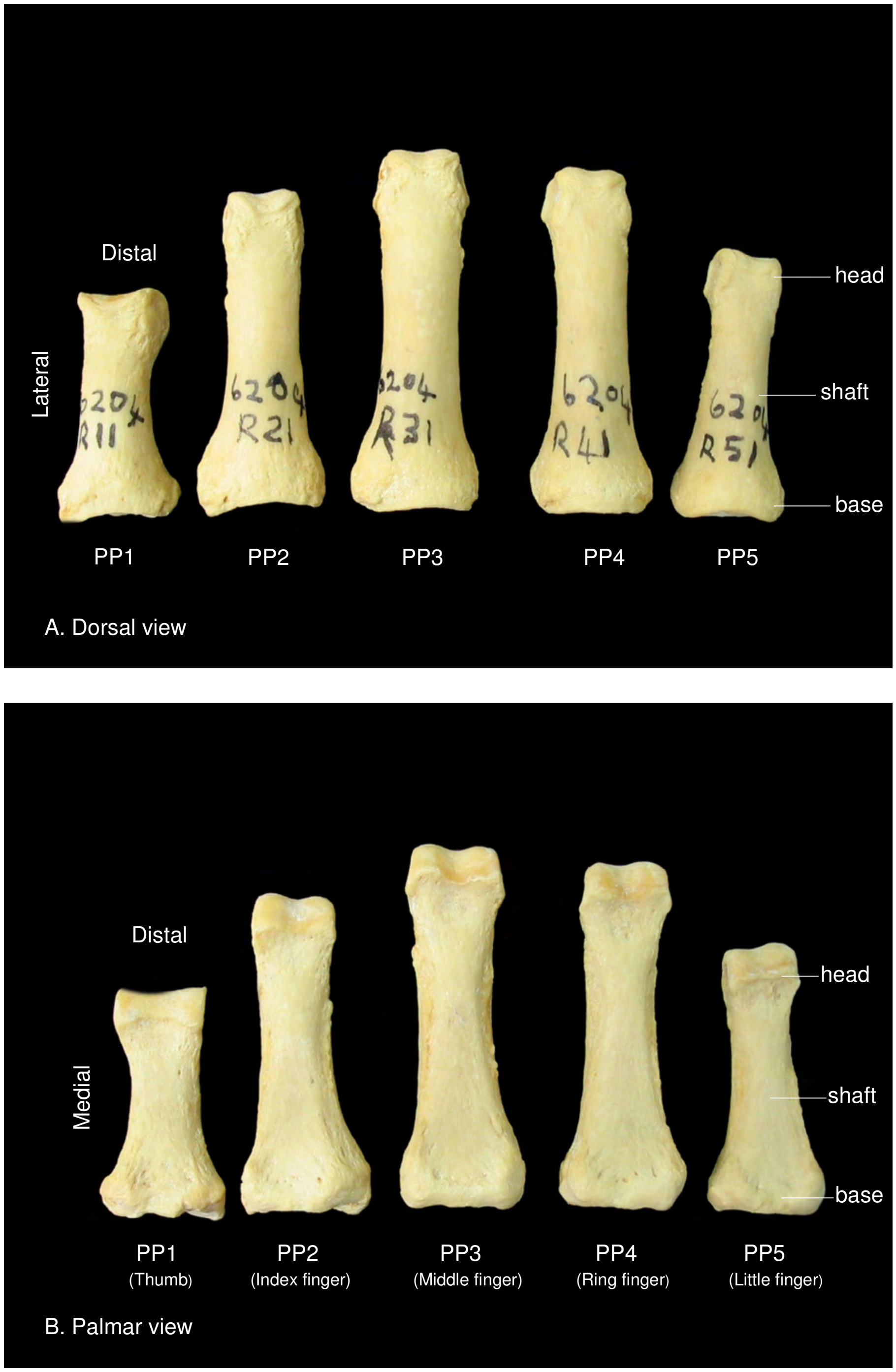


Figure 2.3: Dorsal (A) and palmar (B) view of middle phalanges (MP) 2 to 5 of the right (R) hand.

Figure 2.4: Dorsal (A) and palmar (B) view of distal phalanges (DP) 1 to 5 of the right (R) hand.

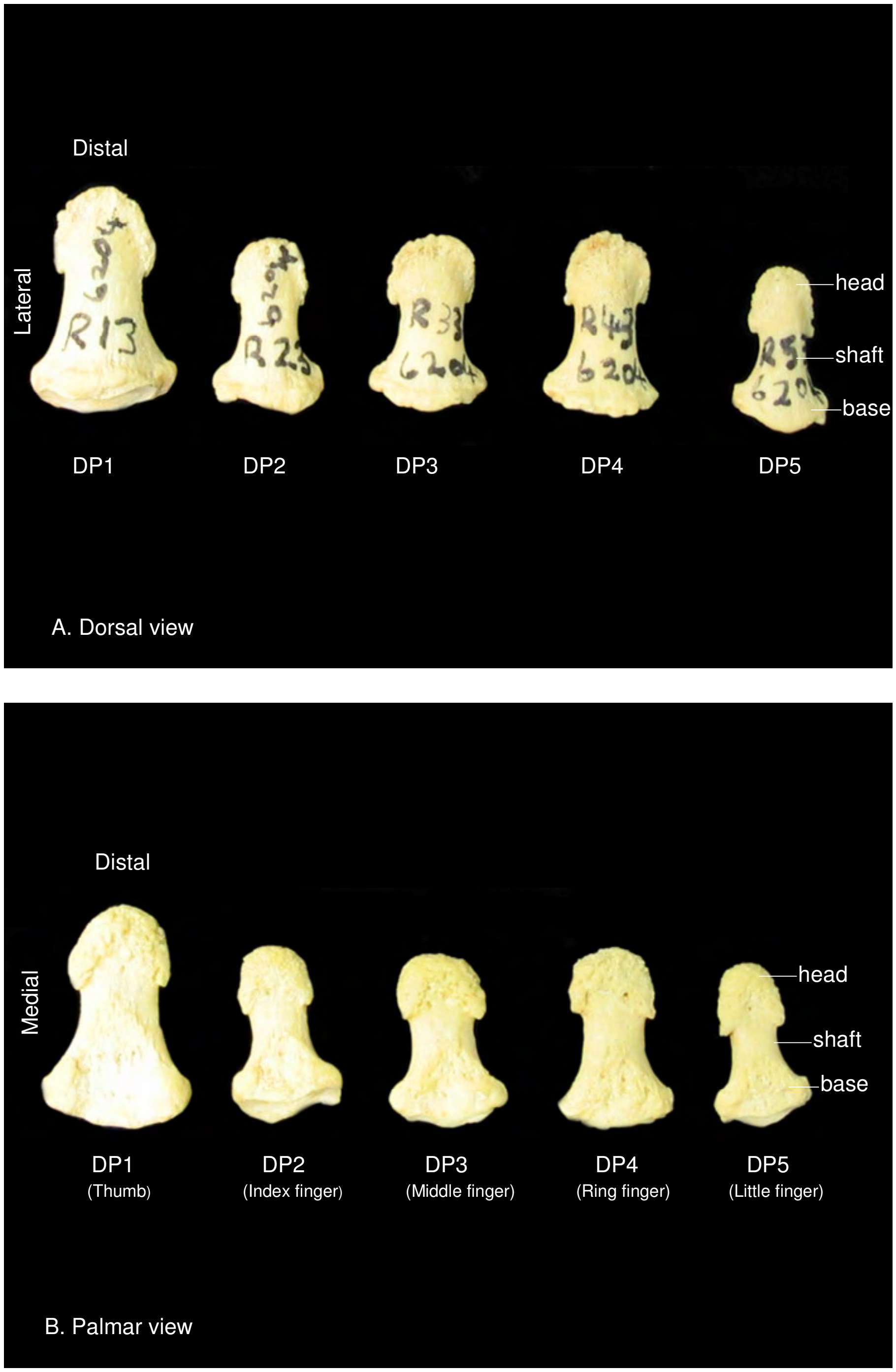


Figure 2.5: Siding techniques for the manual proximal (1-5) and intermediate (2-3) phalanges [Taken from Case DT and Heilman J 2006. International Journal of Osteoarchaeology 16: 338-346 Copyright: 2006 John Wiley & Sons, Ltd.]

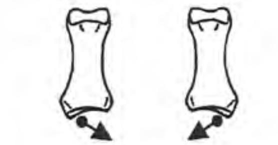
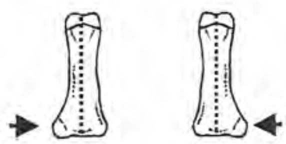
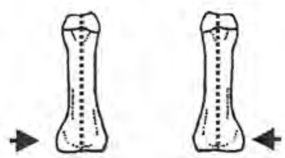
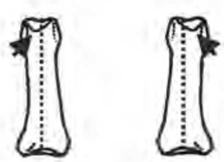
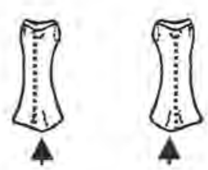
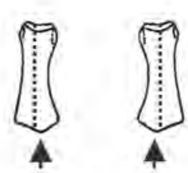
Bone and View (Accuracy)	**Left Side / Right Side**	**Siding Techniques**
Proximal Phalanx I (100%)		PP1: The lateral edge of the proximal facet Palmar faces toward the opposite side the bone is from. Additionally look for the most proximal point to be on the side the bone is from.
Proximal Phalanx 2 Palmar (96%)		PP2: The mass of the proximal end is greater on the side the bone is trom. <u>Additionally</u>, look for the most distal point on the bone to be opposite the side the bone is from.
Proximal Phalanx 3 Palmar		PP3: The mass of the proximal end is greater on the side the bone is from. <u>Additionally</u>, look for the most distal point on the bone to be opposite the side the (94%)bone is from.
Proximal Phalanx 4 Proximal (94%)		PP4: With the bone on its dorsal urface the greatest vertical height on the proximal end is found on the side the bone is from. Use finger pressure on the shaft to keep the bone from rolling. The bone also tends to roll toward the side the bone is from.
Proximal Phalanx 5 Dorsal (88%)		PP5: The margin of the superodistal facet extends more proximal1y on the side the bone is from. <u>Additionally</u>, look for the most distal point on the bone to be opposite the side the bone is from.
Intermediate Phalanx Dorsal (96%)		IP2: The projection of the superior margin of the proximal facet is off-center opposite the side the bone is from.
Intermediate Phalanx Dorsal (96%)		IP3: The projection of the superior margin of the proximal facet is off-center opposite the side the bone is from.

Figure 2.6: Siding techniques for the manual intermediate (4-5)and distal phalanges (1-5) [Taken from Case DT and Heilman J 2006. International Journal 0f Osteoarchaeology 16: 338-346 Copyright: 2006 John Wiley & Sons, Ltd.]

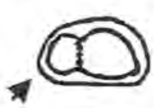
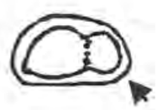
Bone and View (Accuracy)	**Left Side**	**Right Side**	**Siding Techniques**
Intermediate Phalanx 4 Dorsal (78%)			IP4: The most distal point on the bone is on the side the bone is from. <u>Additionally</u>, the shaft of the bone exhibits deeper curvature opposite the side the bone is from.
Intermediate Phalanx 5 Dorsal (98%)			IP5: The most distal point on the bone is on the side the bone is from. <u>Additionally</u>, the shaft of the bone exhibits deeper curvature opposite the side the bone is from.
Distal Phalanx 1 Dorsal (94%)			DP I: One half of the proximal face partially faces toward the side the bone is from. <u>Additionally</u>, the most proximal point on the bone is opposite the side the bone is from.
Distal Phalanx 2 Proximal (52%)			DP2: Looking at the proximal facet with the palmar aspect down, the smaller of the two facets is on side the bone is from. <u>Additionally</u>, look for the facet height to narrow more on the side the bone is from.
Distal Phalanx 3 Proximal (66%)			DP3: Looking for the proximal facet with the palmar aspect down, the smaller of the two facets is on the side the bone is from. <u>Additionally</u>, look for the facet height to narrow more on the side the bone is from.
Distal Phalanx 4 Proximal (68%)			DP4: Looking at the proximal facet with the palmar aspect down, the smaller of the two facets is on the side the bone is from. <u>Additionally</u>, look for the facet height to narrow more on the side the bone is from.
Distal Phalanx 5 Dorsal (78%)			DP5: The shaft of the bone exhibit deeper curvature opposite the side the bone is from.

Table 2.1: Additional siding techniques for the manual phalanges by Case and Heilman (2006) (PP=proximal phalanx, IP-intermediate phalanx)

Bone	Accuracy	Description
PP1	96%	Distal view: Place the bone on a flat surface on its palmar aspect, holding the proximal end down firmly. The distal end does not contact the flat surface opposite the side the bone is from
PP2	94%	Distal view: Place the bone on a flat surface on its palmar aspect, holding the proximal end down firmly. The distal end does not contact the flat surface on the side the bone is from
PP5	82%	Dorsal view: The mass of the proximal base is greater on the side the bone is from
IP2	90%	Proximal view: Lay the bone on a flat surface on its dorsal aspect. The side of the proximal base highest above the flat surface is on te side the bone is from
IP3	90%	Proximal view: Lay the bone on a flat surface on its dorsal aspect. The side of the proximal base highest above the flat surface is on the side the bone is from
IP5	96%	Dorsal view: The degree of curvature of the shaft margin is greater on the lateral side, which is opposite the side the bone is from

Table 2.2: Additional siding techniques for the manual phalanges by Ricklan (1988) (PP=proximal phalanx, IP=intermediate phalanx, DP=distal phalanx)

Bone	Accuracy	Description
PP1	83%	Distal view: With the palmar aspect down, the largest part of the distal articular surface is on the side the bone is from
PP2	82%	Distal view: With the palmar aspect down, the largest part of the distal articular surface is opposite the side the bone is from
PP3	80%	Distal view: With the palmar aspect down, the largest part of the distal articular surface is opposite the side the bone is from
PP5	98%	Palmar view: The most distal point on the bone is on the side the bone is from
IP2	93%	Proximal view: Loking at the proximal facet with the palmar aspect down, the larger of the two facet area is on the side the bone is from
IP3	85%	Proximal view: Looking at the proximal facet with the palmar aspect down, the larger of the two facet areas is on the side the bone is from
DP2	91%	Palmar view: A line tangent to the medial- and lateral-most edges of the proximal articular surface trends distally opposite the side the bone is from
DP3	77%	Palmar view: A line tangent to the medial- and lateral- most edges of the proximal articular surface trends distally opposite the side the bone is from
DP4	57%	Palmar view: A line tangent to the medial- and lateral- most edges of the proximal articular surface trends distally on the side the bone is from
DP5	89%	Palmar view: A line taget to the medial- and lateral- most edges of the proximal articular surface trends distally on the side the bone is from