BIOA201 01/02/2017 Internal Assessment
Osteological Report for "Bone Bag J"

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Contents

List of Figures

1 Introduction

On 1 February 2017 I was presented with 'Bone Bag J' and informed that the bones were found behind a panel during the renovation of a late victorian house in Dunedin. The following is a report on those bones.

1.1 General Methodology

The bones were macroscopically inspected from 01/02/2017 - 13/02/2017 in comfortable laboratory conditions with good natural and overhead lighting in the Histology Laboratory and Anatomy Museum of the University of Otago. They were directly compared to a variety of articulated and disarticulated Indian human bones and also to photographs and drawings of human and animal bones (see references).

This macroscopic method of qualitative resemblance to labelled samples was the primary method employed. See Appendix 1 for a summary table of findings.

2 Findings From Bones

2.1 Ulnar

The bone appears to be a post-cranial long bone. The bone does not look like a human ulna, however, due to it's 3 sided body and the shaft being significantly more reduced. In his discussion of domestic animals Sisson points out that while the distal end of the ulnar is reduced in oxen, it is much less reduced than that of the tapered or dagger end of the foal (Getty, Robert, p.751-752). This bone more closely resembles the bone of the foal but Sisson's discussion is limited to domestic ruminants and he does not consider differentiation between horses, mules, donkeys, zebras etc.

This bone has a crevice proximally which is consistent with the location of the proximal epiphyseal line of the immature ulnar. The distal tip doesn't have spongy bone exposed and there isn't evidence of a sharp line from peri-mortem cortical fracture. Distally there is again no spongy bone exposed which suggests that the bone hasn't been broken peri-mortem. The dagger tip is roughened, however, consistent with the site of interosseus membranous attachment of an immature (pre-fused) ulnar to the radius. Sisson states that the ulnar of the horse is commonly fused proximally and always fused distally by 3.5 - 4 years. (Getty, Robert, p.751-752). He cites a number of authors who place epiphyseal closure times of the distal end determined from gross specimens at 2 - 3 months. Since the distal end does not appear to have been fused (there is no exposed trabecular bone attesting to it's having been broken from the radius peri-mortem) that would put an upper limit on the horses age during life at around 2-3 months.

Morphologically, the shape of the bone highly resembles the one-week old foal, or the four-week shetland colt illustration with an unfused olecranon tuberosity / proximal epiphysis of ulnar (Getty, Robert, p.231, p.281). Unfortunately, no size dimensions are provided. I am unable to determine sex as "the consensus is that any determination (of the sex of a subadult skeleton) is little better than a guess. The secondary characteristics do not manifest themselves until puberty; thus it is impossible to judge the remains of children and adolescents because the means available relate to adult traits" (Bass, p.25).

This may be particularly true for non-human species of ungulates such as horses that are less sexually dimorphic than human beings (e.g., female and male athletes compete together and castration of males doesn't negatively impair athletic performance).

2.2 Vertebrae

The presence of what appears to be a vertebral body, vertebral arch, spinous processes, transverse processes and articular processes indicate this bone is a vertebrae. A heart shaped body, and costal facets on transverse processes for articulation with ribs further indicate it is a thoracic vertebrae. The posterior and most of the lateral sides of the body are no longer covered by cortical bone. The trabecular bone that is exposed is dry, porous, and fragile to the touch. There is evidence of a costal facet on the anterio-lateral superior aspect of the body consistent with it being one of the first 10 but it cannot be determined whether there was a whole costal pit that has partially deteriorated or whether there was only a half pit (see Bass, p.108 for discussion on the significance of this). The spinous process is inferiorly oriented and appears perhaps most consistent with T5 or T6 (Schumacher, Udo, p.86).

This vertebrae doesn't exhibit signs of epiphyseal lines, but since these portions (the transverse and spinous processes) are broken we can't determine whether or not the vertebrae was fused. Bass states that "The vertebrae almost attain their full size by puberty, even though the epiphyses have not yet fused. (Bass, 1995, p.102)". While the size of this vertebra is consistent with others of adult size I can't rule out the possibility of it being pubescent. While the bone is porous and fragile "it is difficult, if not impossible, in most cases (without a chemical analysis of the skeleton) to determine how long an individual has been dead (Bass, p.12)". The low density of trabecular bone is consistent with either advancing age and / or osteoporosis and / or post-mortem deterioration.

2.3 Calcaneus

This bone was identified as most closely resembling a left adult human calcaneus due to size, the absence of epiphyseal lines, and the presence of body landmarks. There are 1.5-2mm diameter holes into the bone: 2 on the posterior articular surface for talus, 1 in the sulcus calcanei, 2 in the middle articular surface for talus, and 5 through the posterior tubercle. When macroscopically compared to calcanei in the 1/2 skeleton sets the holes were similarly sized, numbered, and located with a number of other calcanei that have nylon thread threaded through the holes in order to keep together the bones of the foot. There is writing in black marker that appears to be capital letters of English on the inferior aspect that is hard to make out but appears consistent with 'ANATOMY DEPT.' visible on other bones. Portions of cortical bone on the anterior and posterior aspect of the dorsal surface of the body and also the lateral surface where the anterio-lateral

portion has a large segment of spongy bone removed out of it. The trabecular structure of the underlying bone is apparent and very porous and there is a loose white powder (chalk? cocaine?) in parts of the trabecular bone. There is a surface stain of varnish or (perhaps more likely) preservative or fixative. As in the vertebrae the low density of trabecular bone is consistent with either advancing age and / or osteoporosis and / or post-mortem degeneration.

2.4 Phalanx

This is a long bone that is small in size with no evidence of epiphyseal lines. It appears more consistent with phalanges of the foot rather than the hand and appears to most closely resemble the second proximal phalanx of the foot. I was unable to find a methodology to determine whether it was a right or a left foot. I tried to discover for myself whether there was any left to right a-symmetry that might allow me to identify medial from lateral (and thus left from right) but I was unable to find anything that appeared consistent across a range of full, hung, skeletons. The bone has surface stain that is macroscopically indistinguishable from the surface stain or varnish of the calcaneus. The cortical bone remains but there are large portions absent from the medial and lateral aspect of the proximal end and 2mm diameter holes through the mid-saggital plane of the long axis again consistent with preparation for nylon threading to keep the bone together with other bones of the foot. There is no evidence of epiphyseal fusion lines indicating that this bone belongs to an adult. The bone is hollow - no trabecular bone remains. As in the vertebrae and calcaneus the low density of trabecular bone is consistent with either advancing age and / or osteoporosis and / or post-mortem degeneration.

2.5 Scapula

This bone appears to mostly resemble a scapula with no evidence of epiphyseal lines indicating that it belonged to an adult as "The coracoid fuses with the scapula beginning about the 15th year along a line that includes the upper part of the glenoid cavity, and usually is completed by the 18th year" (Bass, p.118). With the spine oriented posteriorly, the acetabulum laterally, the inferior angle inferiorly the scapula was determined to be the left scapula. The infra-spinous fossa is paper-thin in places and inferior to the spine in black marker appears 'ANATOMY DEPT.' This part of the bone is so thin that the text is visible through the supra-scapular fossa. Bass states that Graves (1922) noted the appearance of "atropic spots" or localized, discrete, or coalescing areas of bone atropy in the older age range (Bass, p.124). These need to be distinguished by degree of translucency, however "there also must be a localized alteration in the vascularity and structure of the bone". I can't see visible evidence of this and therefore cannot determine that this scapular belonged to an older adult more particularly.

There are 5 holes through the infraspinous fossa. They have sharp edges consistent with a brittle post-mortem fracture of the bone as there is no sign of bony healing. The holes appear to be in the thinnest part of the bone and might be consistent with people poking at it to text the texture / consistency / to see how fragile it is. Cortical bone appears to have been post-mortemly chipped off edges or corners including the infrascapular angle, the anterior and the lateral aspect of the acromion process, the coracoid process and the infraglenoid fossa. This is consistent with the bone banging against a hard object (or another bone) being transported around. There is no evidence of healing indicating that these are post-mortem.

2.6 Humerus

This bone appears to be a fairly normal adult humerus. There is no sign of epiphyseal lines. There is some chipping of the cortical bone around the medial aspect of the anatomical neck and no evidence of subsequent healing indicating the damage was peri or post mortem. There are traces of red paint posteriorly around 1/3 of the way down the medial shaft and also around 1/6 of the way down the posterior medical shaft. "The humerus is a poor bone for sex estimation (Bass, p.156)"

2.7 Occipital

This bone appears to be a broad, flat, bone of the cranium. It was identified as being an occipital bone of an adult on the basis of morphological features such as the presence of the foramen magnum and the convex occipital condyles for articulation with the first cervical vertebra (C1).

During life the occipital bone articulates with two parietal bones via the lambdoidal suture, two temporal bones along the mastoid margin, with the sphenoid via the basilar suture, and with the atlas or first cervical vertebrae via the occipital condyles. The complex three dimensional structural arrangement of the bone adjacent to the the lambdoidal suture along with it's cortical covering (the diplotic bone has not been exposed) suggests that the occipital bone had not fully fused into a synostotic joint in life. There is some diplotic bone / trabecular bone exposed along the mastoid margin, however, sugggesting that the bone may have been broken or pried apart from a temporal bone that it was at least partly fused with during life. The basilar structure doesn't show evidence of exposed diplotic bone, instead the cortical outer layer seems preserved which suggests that the sphenooccipital suture had not fused in life."One cranial feature, the sphenooccipital syncondrosis, is particularly useful in aging isolated crania because at least 95% of all individuals have fusion here between 20 and 25 years of age, with a central tendency at 23 years of age (Krogman and Iscan, 1986). Other cranial sutures show more variation in age of closure. (in Folkens, Pieter A, p.371).

The size of the bone is consistent with other human occipital bones with which the

bone was compared. It did not stand out as being particularly large - which might be indicative of a male sexed occipital bone if we assume that the populations are roughly the same (which we can't). The nuchal line didn't appear especially prominant and neither did the external occipital protuberance. Neither of the two bony landmarks or the general size or robustness indicating anything particularly male about the bone. Without knowing more information about the population from which this bone has come I would only be guessing if I attempted to assign gender. I don't have any information about the population and can't tell from macroscopic analysis. Biological affinity also can't be determined by the occipital bone.

The right Lamboid suture has the words 'ANATOMY DEPT.' There are red and blue lines along the superior temporal line consistent with someone running their pen along to point out the bony landmark.

2.8 Hip Bone

The presence of distinguishing bony landmarks strongly indicates that this is a hip bone. For example, the deep concavity of the acetabulum is consistent with the deep ball and socket joint of the hip and not with the much shallower socket of the humerus. The triangular obturator foramen, well preserved pubic symphysis, the broad sweeping surface of the posterio-lateral ilium, and the L shaped auricular surface medially for articulation with the sacrum are all also evidence in favour of this being an innominate bone. When the acetabulum was oriented laterally, the pubic symphysis oriented anteriorly and the iliac crest oriented laterally the bone was determined to be a right hip bone.

The hip bone has been fairly unanimously regarded as the single best bone to consult when attempting to determine the sex of a skeleton. "There are three characteristic areas of the female pubis and ischiopubic ramus that serve to distinguish the sexes in over 95% of cases... The ventral arc, the subpubic concavity, and the medial aspect of the ischiopubic ramus..." (Bass, p.209). This is because around puberty the female hip hone widens in response to hormonal changes that are relatively invariant to alterations in biological affinity, nutritional status, or levels and kind of physical activity. "The greater sciatic notch is near a right angle in the female, much less in the male Last, Jack, p.221.)

Despite holding the bone at arms length and orienting the bone as directed (acetabulum most laterally, ilium (inferred) most superiorly, pubis vertically) I was not able to achieve intra-rater reliability on any of the features to enable me to confidently determine the gender. It really was not for lack of squinting. Even in comparing the bone to others in order to try and assess whether the subpubic angle was greater or lesser than bones marked as male or female the bone didn't stand out to me as being fairly clearly one or the other. I am left having to conclude that this is one of the 5% of cases where the features simply don't serve to determine the sex.

With respect to age, White states that "In Todd's original 1920 work on the changes he

had classified in the pubic symphysis, he took great pains to point out that the most accurate estimate of age can only be made after examining the entire skeleton. However, due to the sometimes fragmentary nature of skeletal remains and the history of development of aging techniques, his advice has often been forgotten by human osteologists who followed (Folkens, Pieter A, p.384)." There are no epiphyseal lines present, suggesting that it belongs to an adult. McKern and Stewart (1957) developed a more objective (rather than qualitative) system for studying the symphyseal surface, but Bass has described it as "complicated and difficult for the unskilled to implement" (Bass, 1995, p.202). Gilbert and McKern (1973) published a method of aging the female *Os pubis* that followed the same general format and standards that were established by McKern and Stewart (1957) for aging males but their system relies on the classifier comparing them to plastic models which I didn't have access to and I was also unable to determine that it was female. "One of the most widely used indicators of age-at-death has been metamorphosis of the symphyseal surface of the pubis of the os coxae... The young adult human pubic symphysis has a rugged surface traversed by horizontal ridges and intervening grooves. This surface loses relief with age and is bounded by a rim by age 35. Subsequent erosion and general deterioration of the surface are progressive changes after this age" (Folkens, Pieter A, p.365). However, the Suchey-Brooks pubic symphysis scoring system should be supplemented by casts before actual aging is attempted (Folkens, Pieter A, p.374-379).

The anterio-superior portion of the pelvis was missing. Jagged edges show no evidence of healing which suggests the fracture occurred close to death or post mortem. The bone was otherwise sturdy and the exposed trabecular bone didn't feel fragile to the touch. The bone had 6mm diameter circular holes through the superior portion of the pubic symphysis and the posterio-superior ilium posterior to the auricular surface. There was no evidence of healing which again suggests the modifications were performed close to death or post mortem. There were traces of green paint in roughly rectangular regions 30x50mm and 30x15 around the holes. There were traces of red paint on the inferior half of the acetabulum, the ischial tuberosity, the ischial spine, the posterior inferior iliac spine, and the auricular surface of the ilium. There were traces of varnish or surface colouring which appeared to emphasise the surface texture of the cortical bone on the anterio-lateral surface. There was evidence of darker colouring on the iliac fossa. All of these modifications are consistent with post-mortem modification for anatomy teaching purposes to emphasise bony landmarks and for hanging up for display.

3 Summary and Interpretation

The minimum number of individuals whose deaths could account for all the bones in the collection is two. The ulna is likely a young horse while the other bones appear to be human. The maximum number of individuals whose deaths could account for all the bones in the collection is eight as it is possible that all the bones are from different

individuals. While the phalanx and calcaneus are similarly stained suggesting that they may have been part of the same specimen I cannot say how many other specimens may or may not have been similarly stained and as such whether or not they belong to the same individual.

The bones were all in good enough condition to stand up fairly well to being handled, transported, and examined though several felt fragile. The bones were not kept in a locked / secured container, however and and a number of people have handled the bones without gloves and hairnets. While the bones were wrapped they also jostled about and microscopic cross contamination and small amounts of deterioration since finding is likely.

My determination is that 7 of the 8 bones are most likely human but that since forensic procedure has not been maintained with respect to the processing and handling of the bones they are unlikely to be admissible as evidence in a court of law. I thus see little to be gained by forensic processing of the site at this stage. It may be profitable to determine whether a person with anatomy department connection had previous tenancy at the house, and with contacting the anatomy department to see whether they are able to further identify the individual/s represented by the bones, and with respect to the possibility of reuniting the bones with others of the same person.

Sex, age, biological affinity are all factors that contribute towards the degree of robustness / gracility of the bones and their bony landmarks and it is very hard to attempt to determine all three rather than attempting to determine one of the factors when the other two are known. Even if we assume the majority of these bones are of a population comparable to others in the anatomy department determining sex and age complicate things. I could attempt to be more precise in my estimates - but then I wouldn't have any faith at all in their accuracy.

References

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Figure 1: Appendix 1

ID	Condition	Element	Part	Side	Age	Sex	Pathology	Other Comments
1	Good	Ulnar	Complete	L	1-4wks	und.	none	nil
2	Poor	Vertebrae	Absent tips of processes	unpaired	Pubsecent-Adult	und.	possible osteo-porosis	low bone density
3	Poor	Calcaneus	Complete	L	Adult	und.	possible osteo-porosis	low bone density. post-mortem modification holes
4	Poor	Phalanx	Complete	und.	Adult	und.	possible osteo-porosis	hollow shell. post-mortem modification holes
5	Good	Scapular	Complete	L	Adult	und.	None	peri-mortem holes
6	Good	Humerus	Complete	L	Adult	und.	None	nil
7	Good	Occipital	Complete	Unpaired	Young Adult	und.	None	nil
8	Good	Hip	Missing portion of superio-lateral ilium	R	Adult	und.	None	post-mortem modification with paint and holes.