2005

Comprehensive examination of the University of Montana Forensic Case 141

Amanda Marie Mason
The University of Montana

Recommended Citation

Mason, Amanda Marie, "Comprehensive examination of the University of Montana Forensic Case 141" (2005). *Graduate Student Theses, Dissertations, & Professional Papers*. 9248.
https://scholarworks.umt.edu/etd/9248

A Comprehensive Examination of The University of Montana Forensic Case 141

By

Amanda Marie Mason

B.A., the University of Evansville

Presented in fulfillment of the requirements

For the degree of

Masters of Arts

The University of Montana

December 2005

Approved by:

Committee Chairman

Dean, Graduate School

12-14-05

Date

Abstract

Mason, Amanda M., M.A., December 2005 Anthropology

A Comprehensive Examination of The University of Montana Forensic Case 141

Committee Chairman: Randall R. Skelton R S.

In this professional paper I examine the skeletal remains of one individual human. The remains were analyzed to obtain information concerning age, sex, ancestry, stature, weight, pathology and trauma that may have occurred before, during, or after death. Forensic anthropologists, who are trained in osteology, use this information to assist law enforcement personnel or for research purposes. Several methods that forensic anthropologists employ were used in the examination of the remains of UMFC 141. The remains of UMFC 141 were observed as being most probably a male of primarily Mongoloid ancestry between the ages of 35 and 44 years. The stature was estimated between 5 feet 2 inches and 5 feet 4 inches and the weight as between 130.2± 25.2 pounds and 136.2± 26.2 pounds. Both premortem trauma and postmortem damage was observed.

Acknowledgements

I would like to thank my mother, Marilou, for always believing in me and pushing me to do better. Thank you to my Aunt Kandy for always knowing what to say to get me through. I would also like to thank Dr. Randall Skelton for all his help and guidance throughout my graduate career and especially with this paper. Thank you to Dr. Ashley Mckeown for your time and assistance with this paper.

Contents

Part I UMFC 141

Appendix

List of tables

INTRODUCTION

From far before the creation of written records people have been fascinated by the concept of justice. The ancient civilizations of Sumer, Egypt, and Greece left behind evidence of this fascination for the entire world to discover thousands of years later. They left behind colorful mosaics, pottery, hieroglyphics, tablets, and pictographs that showed humans' overriding need for justice. Interest in criminal justice has only grown since these ancient civilizations collapsed some hundred or thousands of years ago. Today, issues dealing with criminal justice can be seen in every avenue of modern media. It is quite rare to turn on the television or open a newspaper without seeing some glimpse of justice being played out or thwarted.

Law enforcement officials are the people that we as citizens turn to when we are in need of justice. Before law enforcement can seek justice they must first gather the evidence that is needed to reach their ultimate goal, putting away the bad guy. There are times; however, when evidence is beyond law enforcement officials. The human body provides the most evidence about an individual as long as the person looking at the body knows what to look for. Forensic anthropologists are asked to assist law enforcement personnel when a human body is beyond recognition due to advanced decomposition or when a bone or bones are found. The types of information that forensic anthropologists can conclude from bones include age, sex, racial affiliation, height, weight, pathology, traumas, and sometimes how the individual may have died. This paper will attempt to exemplify what it is that forensic anthropologists can do when asked to evaluate a human skeleton. Case 141 from the University of Montana's forensic lab (UMFC-141) will be studied to estimate age, sex, racial affiliation, stature, weight, handedness, and interpret any pathologies and/or trauma by applying various methods to estimate the above criteria.

THE SKELETAL INVENTORY OF UMFC 141

There are roughly 206 bones in the adult human body. Variations occur in the form of wormian bones that exist within the cranial sutures, sesamoid bones in the hands and feet and extra vertebrae. The human skeleton is divided into two parts, cranial bones and postcranial bones. The cranial bones are the bones of the skull and the postcranial bones include everything else. Bones possess several features to aid in their identification during and after they are recovered. Features include crests, spines, processes, tubercles, grooves, heads, condyles, tuberosities, fossae, foramina, and sinuses. Knowledge of the human skeleton is extremely important to a forensic anthropologist. Without the appropriate knowledge of the human skeleton forensic anthropologists would be unable to identify fragmented bones.

Cranial bones include both single and paired bones. Single bones include the frontal, occipital, sphenoid, mandible, ethmoid, vomer, and hyoid. Paired bones include both left and right sides of the parietals, temporals, maxillae, nasals, zygomatics, lacrimals, palatines, the inferior nasal conchae, and the bones of hearing (malleus, incus, and stapes).

The postcranial skeleton also includes single bones and paired bones of the upper and lower extremities. Single bones include seven cervical vertebrae, 12 thoracic vertebrae, five lumbar vertebrae, the sacrum, coccyx, and sternum of the axial skeleton. Paired bones of the upper extremities include the scapulae, clavicles, ribs (12 each side), humeri, radii, ulnae, carpal bones (8 each side), metacarpals (5 each side), and phalanges (14 each side). Paired bones of the lower extremities include the os coxae, femora, patellae, tibiae, fibulae, tarsals (7 each side), metatarsals (5 each side), and phalanges (14 each side).

There are few instances when a complete skeleton is recovered and identified. The norm for recovery of individual remains consists of many missing skeletal elements. A forensic anthropologist needs to be properly trained to recover an individual with the highest percentage of skeletal elements present. This includes looking for fragmented bones, intact bones, small bones of the hands and feet, as well as the dentition. The more skeletal material provided the easier it will be to try and estimate age, sex, ancestry, stature, weight, pathology, and trauma. Once all criteria are estimated the attempts to properly identify the individual can begin. White and Folkens (1991) believe that the most important thing someone can leave behind is their skeleton and teeth because they are both resilient to various types of decay. Bass (1995) noted that without the existence of skeletal material the information about evolution would simply be lost.

> Bones are the framework of the vertebrate body and thus contain much information about man's adaptive mechanisms to his environment. The study of evolution essentially would be impossible if bones were eliminated as a source of data. In summary, the answer is that bones often survive the process of decay and provide the main evidence for the human form after death. Skeletal evidence also has the potential to provide information on prehistoric customs and diseases. (Bass 1995: 1).

There is very little known about UMFC 141 besides that it is reported the remains were commercially acquired from China by Skeletons Unlimited International. UMFC 141 consists of a complete skeleton with the exception of the hyoid. Many of the skeletal elements exhibit some premortem trauma and pathologies. These will be discussed further in the trauma and pathology section. All skeletal elements that were present were complete and showed slight to no deterioration. All dentition of the mandible and maxillae were present.

SEX ESTIMATION

Sex estimation is widely considered to be easier to estimate than age, ancestry, or stature. Because of "fewer alternatives," the forensic anthropologist has a 50-50 chance of picking either male or female. However, "the human animal is not as neatly divided into typical males and typical females as most people tend to think" (Burns 1999: 151). Sex is essentially the biological construct of either XX or XY chromosomes that determine if a person was born male or female, while gender is a social construct that includes attitudes and behaviors that have been acquired by the individual over time (Walker and Cook 1998). This is why the presence of clothing and/ or jewelry must be taken into consideration only after sex has been determined from the skeleton.

"The most reliable differences... [between males and females]... are in the pelvis" (Burns 1999:151). "An expert can determine sex using the pelvis with about 90% accuracy, but a wise expert will not rely on just one skeletal element for that determination" (Pickering and Bachman 1997: 82). A complete skeleton will yield the best results because "sex determination assessments are more accurate on mature skeletons with accuracy dependent upon skeletal completeness... [the] morphological sexing from a complete skeleton can yield accuracy in the area of 100%" (Walsh-Haney *et al.* 1999: 19-20). Traditionally forensic anthropologists and osteologists have focused primarily on the skull and pelvis because the sex differences are the most noticeable (White and Folkens 1991). However, the forensic anthropologist must be aware that in some populations it is possible to mistake males for females and females for males. This occurs because of the belief that females are smaller overall in size when compared to males. Caution needs to be used when dealing with sexual dimorphism because it varies widely from population to population. Where one population may exhibit a pattern of sexual dimorphism where males are bigger than females another population may have males and females of roughly smaller size. White and Folkens (1991) stress the importance of the forensic anthropologist adequately understanding the skeletal sexual dimorphism of the population that the sample came from. However, sexual dimorphism in pelvic morphology does not vary across populations as cranial sexual dimorphism does because of the constraints placed on female pelvis due to childbirth.

SEX ESTIMATION FROM THE SKULL

UMFC 141 exhibited quite a number of common male traits of the skull. The skull shape of UMFC 141 was rather large and rugged. UMFC 141 exhibited prominent brow ridges with no frontal bossing as well as blunt upper edges of the eye orbits. The right and left mastoid processes were fairly large and the left and right temporals bear suprameatal and supramastoid crests. The nuchal area at the base of the occipital bone was rugged and the nuchal crests were fairly prominent. The chin shape was square with fairly large teeth and palate and the mandible was thick with heavy muscle markings along the gonial region and possessed fairly large mandibular condyles. These features are consistent with patterns of male cranial morphology as depicted in Figure 1.

UMFC 141 displayed typical male characteristics of the skull, with no female characteristics being observed. The combination of these characteristics indicates that UMFC 141 was most likely male.

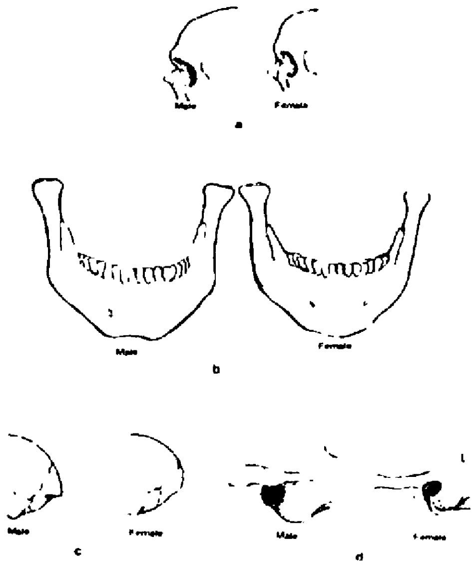


Figure 1 Distinguishing characteristics of the crania used to determine sex: a, brow ridge and forehead; b, the mandible; c, nuchal crest; d, the mastoid process (From Bass 1995: 87).

SEX ESTIMATION FROM THE PELVIS

The pelvis is the most reliable bone from which to estimate sex, and has been characterized as having the highest rate of accuracy (Bass 1995). Morphological traits and Phenice's method, developed in 1969, were applied to estimate the sex of UMFC 141 from the pelvis. Rogers and Saunders (1994) set up a list of morphological features to look at when sexing the pelvis. UMFC 141 displayed all of the characteristics for a male pelvis; a v-shaped sub-pubic concavity, absence of a ridge on the ischiopubic ramus, no ventral arc, narrow pubic bone, small sciatic notch shape and size, flat auricular surface height, no preauricular sulcus, high and vertical ilium shape, and the pelvic outlet was heart shaped and small. Phenice considered the female pelvis to have three characteristics that would always distinguish it from its male counterparts. These characteristics include the ventral arc, the subpubic concavity, and the medial aspect of the ischiopubic ramus

(Rogers and Saunders 1994). It needs to be stated that "in employing the Phenice method to sex os coxae, note that not every specimen is a 'perfect' male or female… [and that] the Phenice method should only be used for fully adult material… [and] the best advice for sexing of the os coxae, as for aging the skeleton, is to use all of the available data" (White and Folkens 1991: 325). Males do not possess a ventral arc, a subpubic concavity, and they display a "flat, broad, and blunt" medial aspect of the ischiopubic ramus. Bass (1995) believes that the ventral arc carries the most weight out of all three characteristics presented by Phenice. See figures 2 and 3 below.

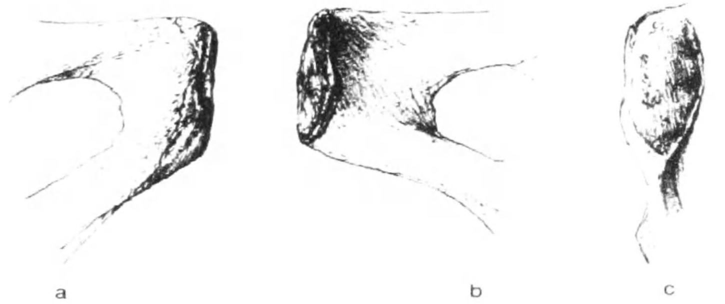


Figure 2 Female pelvis: a, ventral arc; b, subpubic concavity (dorsal surface); c, narrow medial aspect of the ischiopubic ramus (Bass 1995: 211).

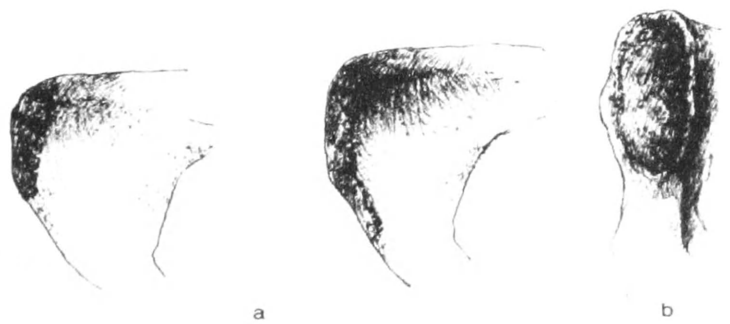


Figure 3 Male pelvis: a, left ventral view (no ventral arc); b, broad medial aspect of the ischiopubic ramus (From Bass 1995: 211).

There were no female traits observed on the pelvis. Male traits included a narrow sciatic notch, which was tested using the "rule of thumb test." The "thumb test" is performed when the thumb is placed in the sciatic notch of the pelvis and is moved around. If minimal side-to-side movement is observed then the individual is a male and if substantial movement is observed then the individual is female (Bass 1995). The "thumb test" can be seen in Figure 4 below.

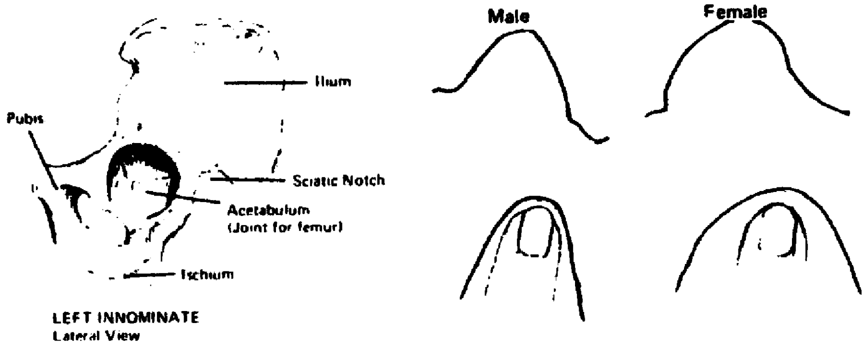


Figure 4 Distinctive criteria useful for ageing and sexing the pelvis; illustrating the Sciatic Notch "Thumb Test" (from Bass 1995: 212-213).

The thumb test was applied to UMFC 141 and illustrated minimal movement. UMFC 141 displayed no preauricular sulcus. The preauricular sulcus can most likely be seen as a depression along the sacroiliac articulation in females, as shown in figure 5 below.

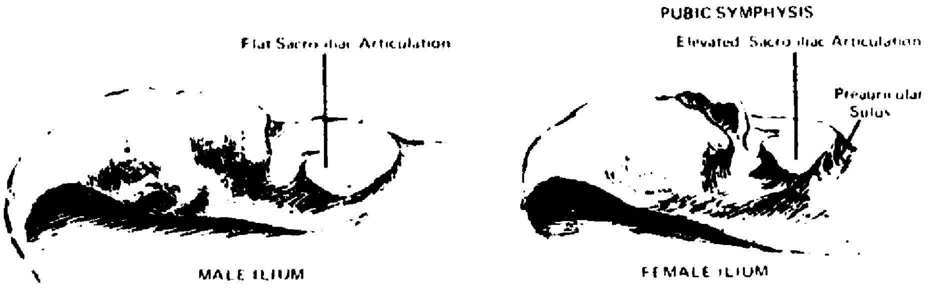


Figure 5 Distinctive criteria useful for ageing and sexing the pelvis; illustrating the pubic symphysis (from Bass 1995: 212).

UMFC 141 displayed a flat sacro-iliac articulation because it is lacking elevation "from the ilium along its entire length and along both the anterior and posterior edges of the sacro-iliac surface, the auricular surface was considered elevated" (Bass 1995: 210).

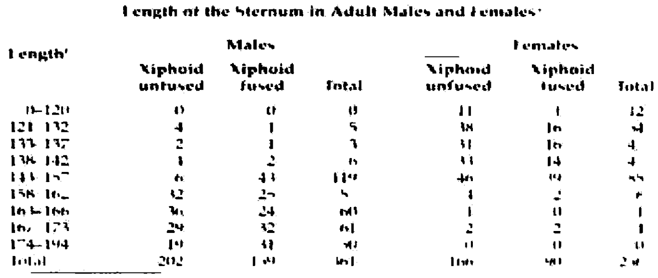
Figure 5 depicts male and female auricular surface morphology. The sacrum of UMFC 141 was curved, the os coxae are robust and have well defined muscle markings, the obturator foramen of the os coxae are large and oval shaped with large acetabulae, and the pelvic basin is narrow and funnel shaped; all of these are male characteristics of the pelvis.

There were no female traits observed on the pelvis of UMFC 141. The findings presented indicate that the remains of UMFC 141 were most probably male.

SEX ESTIMATION FROM BONE MEASUREMENT AND SHAPE

Another way to estimate sex in the adult skeleton is bone measurement and shape. The shape of the pelvis has already been discussed previously; however, the sacrum and sternum are also useful in determining sex from bone shape. The sacrum of UMFC 141 is curved and the relationship between "the body of the sacrum to the ala is greater in males... [Plus,] the sacrum generally is more curved in males and flatter in females" (Bass 1995: 113). The body of the sternum of UMFC 141 is more than twice the length of the manubrium, which indicates a male. Measurements that were taken to determine sex for UMFC 141 came from the sternum, scapula, clavicle, humerus, coxal, and the femur.

In 1980, Jit *et al.* created a formula that utilizes three sternal measurements to establish sex in an individual. Those measurements were the length of the manubrium, length of the mesosternum, and width of the sternebra. It was found that if the sum of the manubrium and mesosternum length was greater than 140mm then the individual was male and if they were less than 131mm the individual was female (Jit *et al.* 1980).The manubrium length of UMFC 141 measured 43.68mm and the mesosternum length measured 101.09mm, giving them a combined length of 144.77mm, which falls in the male range as defined by Jit *et al.* (1980). In 1983, Stewart and McCormick discovered problems with the measurements from the sternum when they observed that measurements were easier to document when the xiphoidal process was not present (Stewart and McCormick 1983). Their results are shown below.



Length of the Sternum in Adult Males and Females

Length	Males			Females		
	Xiphoid unfused	Xiphoid fused	Total	Xiphoid unfused	Xiphoid fused	Total
0–120	0	0	0	11	1	12
121–132	4	1	5	38	16	[illegible]
133–137	2	1	3	31	16	4[illegible]
138–142	[illegible]	2	6	33	14	4[illegible]
143–157	6	43	11[illegible]	46	[illegible]	55
158–162	32	25	[illegible]	4	2	[illegible]
163–166	36	24	60	1	0	1
167–173	29	32	61	2	2	1
174–194	19	41	[illegible]	0	0	0
Total	202	1[illegible]	[illegible]	166	[illegible]	2[illegible]

Figure 6 Measurements showing the relationship between sternal length and sex in adult males and females; all measurements are in mm (From Stewart and McCormick 1983: 218).

Stewart and McCormick concluded that no male sterna length fell below 121mm and no female sterna length fell above 173mm which left an indeterminate overlap of 143-157mm. According to Stewart and McCormick, the combined manubrium and mesosternum length of 144.77mm from UMFC 141 falls into the "unknown" area and sex becomes indeterminate.

Krogman (1962) and Stewart (1979) studied the use of measurements from the scapula to determine sex. In 1894, Dwight noted that two dimensions of the scapula were useful as indicators for.sex: the maximum length between the superior and inferior angles (maximum length) and the length of the glenoid cavity. Stewart tested Dwight's measurements against the Terry Collection and found the glenoid cavity measurements were not well defined. Dwight's results were:

	Females	**Sex Indeterminate**	**Males**
Scapula length	<129mm	140-159mm	>160mm
Glenoid cavity length	<34mm	34-36mm	>37mm

Table 1 Length of glenoid cavity of scapula as related to sex in adults (Dwight 1894 as referenced in Bass 1995: 129).

The maximum length of the left scapula of UMFC 141 measured 150.88mm and the right measured 147.57mm. Both measurements fell into the indeterminate sex area. The glenoid cavity length of the left scapula of UMFC 141 measured 37.64mm and the right measured 39.32mm. These two measurements both fell into the male category.

Sex determination from measurement of the clavicle has been studied by Thieme (1957). Thieme used clavicle length as one of eight measurements to determine sex in the American Black skeleton. Thieme reported the following results from using clavicle length to predict sex:

Measurement	**Sex**	**N**	**Mean (mm)**	**Standard Deviation**	**Stand Error**	**Critical Ratio**
Clavicle Length	M	98	158.24	10.06	1.158	13.90
	F	100	140.28	7.99	0.800	

Table 2 Sex estimation from clavicle length in adult males and females (from Thieme 1957: 73).

Thieme's male range results encompass 148.18mm-168.30mm while the female range includes 132.29mm-148.27, with an overlap of only .09mm. The maximum length of the left clavicle from UMFC 141 measured 129.77mm while the right measured 135.49mm, putting both clavicles well into the female range. Although Thieme conducted his study on an American Black population he still believed that this data could be used for other races as well.

> The criteria applicable to one race may be useful for any other if the appropriate limit values discriminating between the sexes can be established… [When determining] the degree of sex differences within [a] population… we can probably operate effectively on the assumption that this is a constant value for all human varieties… [and] if the mean values by sex for the measurements [taken] were known for any other race, an appropriate limit which would be applicable to an individual specimen can be calculated quite easily (Thieme 1957: 78-79).

Thieme may not be the best method to use to determine sex because of the racial affiliation of UMFC 141. Thieme provides some of the only data that can be used to estimate sex from the clavicles. The results given by Thieme's data sets should be treated with caution because of their inherent lack of reliability when applied to other races because clavicle measurements to estimate sex have been found to be notoriously unreliable (Bass 1995). The measurements from the left and right clavicles of UMFC 141 are placed within the female range.

Bass (1995) believes that humeri are poor bones to use when estimating sex; however, Dwight (1905), Stewart (1979), and Thieme (1957) have all conducted studies using measurements from the humerus as a way to determine sex. Dwight studied the diameter of the humeral head, his results were:

	Vertical	**Transverse**
Male	48.76mm	44.66mm
Female	42.67mm	36.98mm
Difference	6.09mm	5.68mm

Table 3 Sex estimation from the measurements of the humeral head (from Dwight 1905: 19-32)

Stewart also studied the vertical diameter of the humeral head as a means of estimating sex. His results were:

	Females	**Sex Indeterminate**	**Males**
Vertical diameter of the humeral head	<43mm	44-46mm	>47mm

Table 4 Sex estimation from measurements of the vertical diameter of the humeral head (from Stewart 1979: 100).

The maximum vertical diameter of the left humeral head from UMFC 141 measured 45.35mm and the right measured 46.21mm while the transverse diameter of the left humeral head measured 44.21mm and the right measured 44.53mm. The vertical diameters of the left and right humeral head of UMFC 141 fell between the two sexes using the data Dwight and Stewart supplied. The transverse diameters of the left and right humeral head fell very close to but not within the male range. This method gives a sex determination of indeterminate. Thieme studied the epicondylar width and maximum length of the humerus to determine sex in American Black skeletons. His results were:

Measurement	**Sex**	**N**	**Mean (mm)**	**Standard deviation**	**Standard error**	**Critical ratio**
Humerus length	M	98	338.98	18.55	1.874	12.51
	F	100	305.89	18.66	1.866	
Epicondylar width	M	98	63.89	3.59	0.363	14.50
	F	100	56.76	3.32	0.332	

Table 5 Sex estimation using the humerus of American Negroes (from Thieme 1957: 73).

The maximum length of the left humerus from UMFC 141 measured 285mm and the right measured 290mm. According to the data supplied by Thieme, the male range would include 320.43mm-357.53mm and the female range would include 287.23mm-324.55mm with an overlap of 4.12mm. The right and left maximum lengths taken from UMFC 141 places the sex of this individual within the female range. The epicondylar width of the left humerus from UMFC 141 measured 60.06mm and the right measured 60.48mm. The male range for epicondylar width given by Thieme would include 60.30mm-67.48mm and the female range would include 53.44mm-60.08mm. Given these ranges and the measurements taken from UMFC 141, the left humeral epicondylar width would fall into the female range while the right humeral epicondylar width falls within the male range.

In 1986, Dittrick and Suchey "studied sexual dimorphism of both the femur and humerus using prehistoric skeletal samples from central California... The best single indicator for the humerus is transverse diameter of the head. Accuracy obtained with this one measurement alone is 96% in Early Horizon, 86% in the combined Middle and Late horizons, and 88% for all horizons combined" (Dittrick and Suchey 1986 as referenced in Bass 1995: 157-158). Their results were (referenced in Bass 1995):

Sample	**Male**	**Female**	**Male mean(mm)**	**Female mean**	**Accuracy (%)**
Early Horizon	>42.8	<42.8	44.5	39.6	96
Middle and Late Horizon	>40.9	<40.9	43.3	38.6	86
Combined Horizon	>41.2	<41.2	43.5	38.6	88

Table 6 Sexing by transverse diameter of the head of the humerus in Prehistoric samples from central California (N=258) (Dittrick and Suchey 1986 as referenced in Bass 1995: 162).

The transverse diameter of the left humeral head measured 44.21mm and the right measured 44.53mm, both of which fall into the male range in the Early, Middle and Late, and combined horizons from the data provided by Dittrick and Suchey.

The os coxae can also be measured to help aid in sex determination. Washburn (1948) and Montague (1960) have both studied the measurements of the os coxae and how they can help in sex identification; however, measurements of the os coxae and their results are tied into racial affiliation. The racial affiliation of UMFC 141 will be discussed in the racial section; however, for the purpose of this method UMFC 141 will be assessed using both racial indices. The measurement of the os coxae that helps in sex determination is that of the Ischium-Pubis index. "The index averages 15% higher in females than males, and the sex of over 90% of skeletons can be determined by this index alone, provided major racial groups are treated separately" (Washburn 1948: 206). Bass provides the following data from Washburn's study:

Whites (N=200)	**Negroes (N=100)**
Below 90= male	Below 84= male
90-95= indeterminate sex	84-88= indeterminate sex
95+ = female	88+ = female

Table 7 Sex estimation from the Ischium-Pubis Index (from Bass 1995: 200).

Montague (1960) provided the following results of this index towards sex determination:

	Mean	**Range**
White male	83.6±4.0	73-94
White female	99.5±5.1	91-115
Negro male	79.9±4.0	71-88
Negro female	95.0±4.6	84-106

Table 8 Indicators of sex using the Ischium- Pubis Index (from Montague 1960: 629).

The formulae for determining the Ischium-Pubis Index is as follows:

$$\text{Ischium-Pubis Index} = \frac{\text{pubis length x 100}}{\text{ischium length}}$$

The left pubis length for UMFC 141 measured 68.99mm and the right measured 68.94mm while the left ischium length measured 80.03mm and the right measured

80.50mm. The calculations for the left Ischium-Pubis Index (IPI) for UMFC 141 are shown below:

$$IPI= 68.99 \times 100/ 80.03= 86.21mm$$

The calculations for the right Ischium-Pubis Index (IPI) for UMFC 141 are shown below:

$$IPI= 68.94 \times 100/ 80.50= 85.64mm$$

When these measurements are compared to both the Washburn and Montague results they fall into the male ranges when associated with American White ancestry and into the indeterminate range when associated with American Black ancestry.

The femur, according to Bass, is one of the most studied bones in the human skeleton and can contribute to sex determination. The following results are from Pearson studies between 1917 and 1919 on using measurements of the femur as a basis for estimating sex:

	Female(mm)	Female?	Sex?	Male?	Male
Vertical diameter	<41.5	41.5-43.5	43.5-44.5	44.5-45.5	>45.5
Popliteal length	<106	106-114.5	114.5-132	132-145	>145
Bicondylar width	<72	72-74	74-76	76-78	>78
Trochanteric oblique length	<390	390-405	405-430	430-450	>450

Table 9 Rules for sexing the femur (Pearson 1917-1919 as referenced in Bass 1995: 230).

Stewart studied Pearson's results and stated that he felt "reasonably safe in recommending the following adjustment in Pearson's… [vertical diameter] range subdivision for use in sexing the dry bones of American Whites" (Stewart 1979: 120). See table 10 below.

Female (mm)	Female?	Sex?	Male?	Male
<42.5	42.5-43.5	43.5-46.5	46.5-47.5	>47.5

Table 10 Adjustments in Pearson's range subdivision for use in sexing the greatest diameter of the femoral head of American Whites (from Stewart 1979: 120).

Thieme provided the following results on femoral measurements of Negro skeletons:

Measurement	Sex	N	Mean(mm)	Standard deviation	Standard error	Critical ratio
Femur length	M	98	477.34	28.37	2.866	10.13
	F	100	439.10	24.55	2.456	
Femur head diameter	M	98	47.17	2.75	0.278	16.17
	F	100	41.52	2.12	0.212	

Table 11 Sex estimation using femur length and head diameter from American Negroes (from Thieme 1957: 76).

Measurements of the left and right femora of UMFC 141 were taken and they yielded the following results:

Measurement	Left (mm)	Right
Maximum length	399	395
Vertical diameter	45.32	43.41
Popliteal length	127.75	125.30
Biocondylar width	72.29	71.79
Trochanteric oblique length	385	383

Table 12 Sex estimation of femora measurements from UMFC 141.

When measurements of the left and right femora from UMFC 141 were compared to Pearson's results they fell into the following ranges: the left vertical diameter fell into the ***Male?*** range and the right fell into the ***Female?*** range; the left and right popliteal lengths fell into the ***Sex?*** range; the biocondylar width of the left femur fell into the ***Female?*** range and the right fell into the ***Female*** range; and the left and right trochanteric oblique lengths fell into the ***Female*** range. When Stewart's corrections were applied to Pearson's vertical diameter results both the left and right vertical diameters of UMFC 141 fell into the ***Sex?*** range. The maximum lengths of the left and right femora of UMFC 141 fell outside both male and female ranges when they were applied to Thieme's results while the left femoral head diameter fell into the **Male** range and the right into the **Indeterminate** range. These skewed results are more than likely associated with the anterior-posterior curvature of both the left and right femora of UMFC 141 (see pathology and trauma section). This curvature of the left and right femora would greatly affect the measurements needed to appropriately determine sex.

The tibia and fibula are also bones that can be measured to associate sex with an individual but these two bones were not used to help estimate sex in UMFC 141 because of the perimortem trauma sustained to each bone that made measurements unreliable (see pathology and trauma section).

SEX ESTIMATION FROM DISCRIMINANT FUNCTION ANALYSIS

Sex can also be estimated using discriminant functions developed by Giles and Elliot (1963). Sex is determined by inspection of a score generated when each measurement is multiplied by the suitable coefficient and the product is added or subtracted as indicated by the formula. The score that is generated is called the discriminant score and sex is estimated by whether the discriminant score falls above or below a sectioning point. The accuracy of this method is 70% (Giles and Elliot 1963). See appendix II for a reference of craniometric measurements. The formula is as follows:

2.184(g-op) + 1.000(eu-eu) + 6.224(zy-zy) + 6.122(po-ms) = [1495.40] 70%

To apply this formula the craniometric measurements of g-op, eu-eu, zy-zy, and po-ms will need to be plugged into the appropriate spots within the formula and calculated as indicated. All measurements are in mm. The sectioning point is 1495.40 and if the result falls above this sectioning point it is male and if the result falls below the sectioning point it is female. This method was applied to UMFC 141 to estimate sex, the results are as follows:

2.184(179) + 1.000(125) + 6.224(131) + 6.122(29) = 390.936 + 125 + 815.344 + 177.538= 1508.818mm

A discriminant score of 1508.818mm is >1495.40, which indicates the specimen as male.

CONCLUSIONS

Morphological features of the skull, coxal, and sternum all indicated male. When a discriminant function was applied to the craniometric measurements of UMFC 141 the results estimated sex as male. Discrepancies concerning the estimation of sex came within the measurements of other less reliable bone elements as well as when dealing with racial affiliation. The less reliable methods were based on body size and yielded ambiguous and inconsistent results while those methods based on shape of the pelvis and skull clearly and unambiguously indicated male. Overall, when dealing with the more reliable methods over those that are less reliable the sex of UMFC 141 is most probably male.

AGE ESTIMATION

There are quite a few methods that exist to aid the forensic anthropologist in estimating the age of an individual from skeletal material. Bones as well as teeth are suitable to estimate age in an individual; however, there are some methods and some bones that are better suited than others. Choosing the right method and the right bone could possibly be the hardest part about estimating age.

AGE ESTIMATION FROM EPIPHYSIS CLOSURE

Age from epiphysis closure is particularly useful for estimating age in adolescents. The information that we get from epiphysis closure for adults is that the epiphyses of all bones are fused and at what age they normally fuse. This information gives us a possible minimum age of an adult.

The medial clavicle epiphyses of UMFC 141 were completely fused. The epiphysis of the medial clavicle fuses completely by 18-25 years of age. This age indicates that this individual was at least 25 years of age at the time of death. The epiphyses of the left and right humeri of UMFC 141 were completely fused. The distal epiphysis of the humerus fuses completely by 17-18 years of age, the head of the humerus fuses completely by 24 years of age, and the medial epicondyle of the humerus fuses completely by age 19 (Bass 1995). These ages indicate that this individual was at least 24 years of age at the time of death. The epiphyses of the left and right radii and ulnae of UMFC 141 were completely united. The epiphyses of the ulna and radius, according to Bass, unite simultaneously with one another. The proximal epiphyses of the ulna and radius unite completely by 15-18 years of age and the distal epiphyses unite completely by 17-19 years of age (Bass 1995). These ages indicate that this individual was at least 19 years of age at the time of death. The epiphyses of the left and right femora of UMFC 141 were completely fused. The head of the femur fuses completely by 14-19 years of age and the distal epiphysis fuses by 20-22 years of age (Bass 1995). These ages indicate that the age of this individual was at least 22 years of age at the time of death. The epiphyses of the left and right tibiae of UMFC 141 were completely fused. The distal epiphysis of the tibia fuses completely by 20 years of age and the proximal epiphysis fuses completely by 23 years of age (Bass 1995). These ages indicate that this individual was at least 23 years of age at the time of death. The epiphyses of the left and right fibulae of UMFC 141 were completely united. The distal epiphysis of the fibula unites completely by 14-15 years of age and the proximal epiphysis by 16-17 years of age (Bass 1995). These ages indicate that this individual was at least 17 years of age at the time of death.

As stated earlier, the method of epiphysis closure is not an appropriate method to use with adults because it only provides a possible minimum age at the time of death for an adult. The ages that the epiphysis closure method yielded were combined and UMFC 141 must have been at least 25 years of age at the time of death.

AGE ESTIMATION FROM CRANIAL SUTURE CLOSURE

Estimating age from cranial suture closure is seen as reliable because most everyone can agree on what the sutures say but they should still be used cautiously (Skelton 2003). Todd and Lyon developed their method of age estimation based on endocranial and ectocranial sutures back in 1924. Endocranial sutures are the sutures that can be seen from the inside of the skull and ectocranial sutures can be seen from the outside of the skull. Todd and Lyon's method is explained below.

	Endocranial		**Ectocranial**	
Suture	Commencement	Termination	Commencement	Termination
Sagittal	22	35	20	29
Coronal	24	41	26	50
Lambdoidal	26	47	26	31
Masto-occipital	30	81	28	32
Spheno-temporal	30	67	36	never

Table 13 Age estimation from cranial suture closure; the Todd and Lyon method (Todd and Lyon 1924 as reference in Skelton 2003)

Skelton describes the method by assigning the five endocranial and ectocranial sutures as being open, commenced, or terminated and provides the following steps to adhere to (Skelton 2003: 9-10):

1. For open sutures, score the age as younger than the age listed in the commencement column.
2. For commenced sutures, score the age as older than the age in the commencement column, but younger than the age in the termination column.
3. For terminated sutures, score the age as older than the age in the termination column.
4. Take the information from each suture into account by combining the ages from the 5 sutures to make the most logical pattern. It is very common for the sutures to give inconsistent results.

The Todd and Lyon method was applied to the skull of UMFC 141 and the following suture closure results were observed.

	Endocranial sutures		**Ectocranial sutures**	
Sagittal:	commenced	22-35	commenced	20-29
Coronal:	commenced	24-41	commenced	26-50
Lambdoidal:	commenced	26-47	commenced	26-31
Masto-occipital:	commenced	30-81	commenced	28-32
Spheno-temporal:	commenced	30-67	commenced	>36

Table 14 Suture scores for UMFC 141.

The broad range of using Todd and Lyon's method yielded 20-81 years of age and the narrow range yielded 28-30 years of age.

Baker developed a method in 1984 for estimating age from cranial suture closure and it is similar to the Todd and Lyon method. There are quite a few marked differences between the two methods that can be seen in their respective tables (see tables 13 and 15). Baker's table is shown below.

Suture	**Open**	**Commenced**	**Terminated**
Sagittal Endocranial	<36	19-79	>25
Sagittal Ectocranial	<88	19-83	>33
Lambdoidal Endocranial	<71	22-79	>25
Lambdoidal Ectocranial	<85	24-89	>35
Coronal Endocranial	<71	19-74	>22
Coronal Ectocranial	<85	24-84	>22

Table 15 Age estimation from cranial suture closure; the Baker method (Baker 1984 as referenced in Skelton 2003).

The Baker method was applied to the skull of UMFC 141 and the following suture closure results were observed.

Sagittal Endocranial:	commenced 19-79
Sagittal Ectocranial:	commenced 19-83

Lambdoidal Endocranial: commenced 22-79

Lambdoidal Ectocranial: commenced 24-89

Coronal Endocranial: commenced 19-74

Coronal Ectocranial: commenced 24-84

The Baker method yielded a broad range of 19-89 years of age and a narrow range of 24-74 years of age.

Meindl and Lovejoy developed the suture site method in 1985 as another method to determine age from cranial suture closures. The method works when 10 suture sites in 1cm segments are observed as being open (0), minimal closure (1), significant closure (2), and complete obliteration (3) (White and Folkens 1991). A description of the suture sites are described below.

Midlambdoidal (1): Midpoint of each half of the lambdoidal suture

Lambda (2): Intersection of sagittal and lambdoidal

Obelion (3): At obelion

Anterior Sagittal (4): One-third the distance from bregma to lambda

Bregma (5): At bregma

Midcoronal (6): Midpoint of each half of the coronal suture

Pterion (7): At pterion, the region of the upper portion of the greater wing of the sphenoid, usually at the point at which the parietsphenoid suture meets the frontal bone

Sphenofrontal (8): Midpoint of the sphenofrontal suture

Inferior Sphenotemporal (9): Point of the sphenotemporal suture lying at its intersection with a line connecting articular tubercles at the temporo-mandibular joint

Superior Sphenotemporal (10): Point on the sphenotemporal suture lying 2 cm below its juncture with the parietal bone

Table 16 Definitions of ten observation sites for the suture site method (from Moore-Jansen *et al.* 1994: 10).

The ten observation sites for this method are shown in figure 7 below.

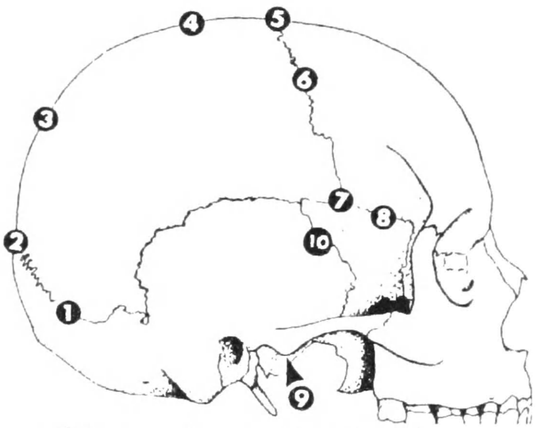


Figure 7 Location of the ten observation sites for the suture site method (from Moore-Jansen *et al.* 1994: 10).

Meindl and Lovejoy found that the method could be bettered if the vault sites and the lateral-anterior sites were divided into two groups and then scored, 1-7 are considered as vault sites while 6-10 are considered as the lateral-anterior sites (Byers 2002). Once each site is scored the total is added an appropriate stage is determined and matched to table 17 below.

Composite score (vault)	Stage	Composite score (lateral-anterior)	Stage
1-2	S1	1	S1
3-6	S2	2	S2
7-11	S3	3-5	S3
12-15	S4	6	S4
16-18	S5	7-8	S5
19-20	S6	9-10	S6
		11-14	S7

Table 17 Age estimation from composite scores of vault and lateral-anterior sutures (from Byers 2002)

Once a stage has been determined from the composite score the age is determined by matching the information to the chart seen figure 8 below.

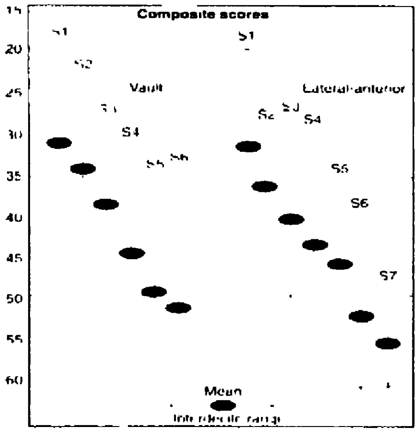


Figure 8 Chart showing relationship between closure and age (from Byers 2002).

The suture site method was applied to UMFC 141 and the following results were obtained.

Scores

1 Midlambdoidal =1
2 Lambda =2
3 Obelion =2
4 Anterior Sagittal =2
5 Bregma =3
6 Midcoronal =2
7 Pterion =1
8 Sphenofrontal =1
9 Inferior Sphenotemporal =1
10 Superior Sphenotemporal =0

The vault sites (1-7) yielded a composite score of 13, which correlates with a mean age of 45. The lateral-anterior sites (6-10) yielded a composite score of 5, which correlates with a mean age of 40.

AGE ESTIMATION FROM DENTAL ATTRITION

There are quite a few methods that have been developed concerning estimating age from dental attrition. Dental attrition "is a way to estimate how old an individual is by the extent of...wear on the teeth. Dental attrition aging is fairly reliable within a population, after the rate of dental attrition has been calculated for that population" (Skelton 2003: 12). This method is broken into two parts by Skelton (2003). The first step is scoring the amount of attrition present on the dentition and the second step is associating the amount of attrition with an appropriate age (Skelton 2003). All of the teeth were present with UMFC 141 but only the upper maxillary teeth were used for this method. The central and lateral incisors scored a 3, which indicates that the dentine exposure was a line of discrete thickness. The score of 3 corresponds with an age of 18-24 years of age. The canines of UMFC 141 scored a 1, which corresponds with some wear but having no dentine exposed. This score of 1 indicates an age of 14-20 years of age. The left and right premolars scored a 5 on average, which correlates with two patches of dentine that are exposed and have coalesced. The score of 5 corresponds with an age of 20-45 years of age. The first right and left molars both scored a 5, the left and right second molars scored a 4, and the left and right third molars scored a 3. The score of 5 corresponds with dentine exposure on all cusps, one of which is a pinpoint. The score of 4 correlates with dentine exposure on three cusps, one of which is a pinpoint and the score of 3 corresponds with dentine exposure on two cusps with one as a pinpoint. The score of 5 from the left and right first molars indicates an age of 17-35 years of age. The score of 4 from the left and right second molars indicates an age of 20-40 years of age. The score of 3 from the left and right third molars indicates an age of 22-50 years of age.

The broad range that this method yielded was 14-45 years of age and a narrow range of 20-35 years of age.

Lovejoy *et al.* (1985) found that "the best single indicator for determining age at death in skeletal population is dental wear [because] it is consistently without bias and probably presents the highest accuracy as well" (Lovejoy *et al.* 1985: 12). The Lovejoy *et al.* method was separated into phases for the right maxillary and left mandibular dentitions. The left mandible scored a stage D while the maxillary scored a stage of F. The mandible score of D correlates with an age of 24-30 years of age while the maxillary score of F corresponds with an age of 30-35 years of age. The broad range of this method is 24-35 years of age and the narrow range is 30 years of age at the time of death.

The most popular method in dental attrition aging was developed by Brothwell in 1965 when he studied samples from the teeth of premedieval British skulls. His results are shown below in figure 9.

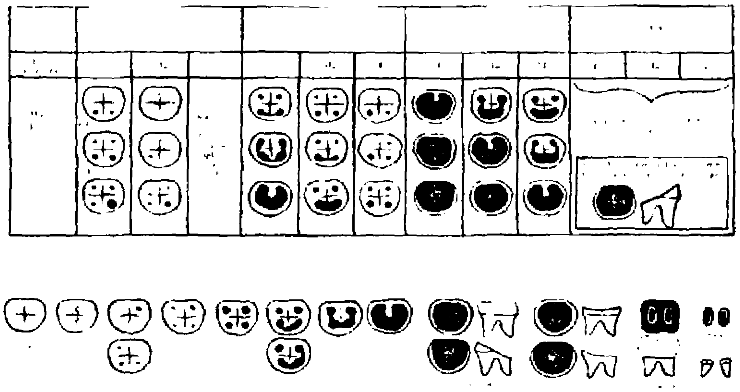


Figure 9 Correlation of age at death with molar wear in Premedieval British skulls (from Brothwell 1972: 69 Figure 30)

This method is based on comparison between Brothwell's chart seen in Figure 9 and the dentition from UMFC 141. The age range given was between 17-35 years of age at the time of death. These results were reached by comparing the molars of UMFC 141, including the upper right first molar (RM^1), the upper left first molar (LM^1), the upper right second molar (RM^2), the upper left second molar (LM^2), the upper right third molar (RM^3), the upper left third molar (LM^3), the lower right first molar (RM$_1$), the lower left first molar (LM$_1$), the lower right second molar (RM$_2$), the lower left second molar(LM$_2$), the lower right third molar (RM$_3$), and the lower left third molar (LM$_3$). With the exception of LM$_3$ and RM$_3$, the dental score was 25-35 years of age while the two exceptions ranged in age from 17-25 years of age.

AGE ESTIMATION FROM THE PUBIC SYMPHYSIS AND AURICULAR SURFACE

The pubic symphysis is located where the two os coxae would most closely approach one another. The auricular surface can be found along the medial surface of the ilium where the sacrum articulates with the os coxae (White and Folkens 1991). Bass (1995) believes that the pubic symphysis is one of the best areas to determine adult age at death. There were several methods applied to UMFC 141 to estimate age from the pubic symphysis. These include the Todd method developed in 1920, the McKern and Stewart method developed in 1957, and the Katz and Suchey method developed in 1986. Age from the auricular surface was estimated using the Meindl *et al.* method developed in 1985. Before the estimation of age can begin using these methods, Skelton advises following the steps shown below:

1. Familiarize yourself with the regions of the auricular surface [and pubic symphysis].
2. Examine illustrations and textual descriptions to find the best match for the auricular surface [and the pubic symphysis] of the specimen you are working with, among the stage definitions. Use the pictures as an aid in doing this, but

remember that it's more reliable to use the text definitions than to simply match your specimen to a picture.

3. When the best match is obtained, assign the age given with the description of that stage to the specimen (Skelton 2003: 32-33).

The left and right os coxae were estimated by comparing the os coxae of UMFC 141 to pictures and textual descriptions of the above mentioned methods. These descriptions and pictures can be found in Bass (1995), Skelton (2003), and Lovejoy *et al.* (1985).

Age from the auricular surface was estimated using the Meindl *et al.* method which can be found in Skelton (2003). The left and right auricular surfaces of UMFC 141 were estimated at stage J because this stage shows the transformation of the surface from coarse to dense (Skelton 2003). This stage corresponds with an age range of 40-44 years of age at the time of death. The pubic symphyses of the left and right os coxae of UMFC 141 displayed a number of stages throughout the methods applied. When the Todd method was applied the 7th phase was the most similar to that of UMFC 141. This stage is equal to 35-39 years of age at the time of death because the face and ventral aspect have changed from the granular texture to that of a fine-grained or dense bone appearance (Bass 1995). The McKern and Stewart methods yielded an estimate of component III-2 which corresponds to an age range of 24-39 years of age at the time of death because component III-2 correlates with the dorsal rim being complete and the ventral rim is beginning to form (Moore-Jansen *et al.* 1994). The Katz and Suchey stage yielded a stage 5 that correlates with an age range of 39-45 years of age at the time of death because the symphyseal face is entirely rimmed with only some minor indentations of the face and the existence of more distinct rimming occurs on the dorsal margin (Moore-Jansen *et al.*

1994). When these age estimates are combined a broad range of 24-45 years of age and a narrow range of 39 years of age was estimated for UMFC 141.

AGE ESTIMATION FROM STERNAL RIB ENDS

Iscan *et al.* (1984) developed a method based on phase analysis of the 4th right rib from 118 autopsied white males. They stated that "the distribution of specimens into phases was based on changes noted in the form, shape, texture, and overall quality of the sternal rib" (Iscan *et al.* 1984: 1095-1096). The 4th rib of UMFC 141 was estimated at being between the 4th and 5th phases. These stages correlate with the ages of 34.4-42.3 and 44.3-55.7. An age range of 34.4-55.7 was concluded from this method.

MULTIFACTORIAL AGE ESTIMATION

Osteologists generally agree on what methods to apply when aging immature skeletal material but they are strongly divided on what methods to apply when aging mature skeletal material. This division is strongly affected because "the value of the skeletal age indicators has been judged in the basis of accuracy (differences between predicted and actual ages) without due regard to bias (the tendency of a given technique to over or underage)" (White and Folkens 1991: 319-320). It is commonly agreed among forensic anthropologists that if more than one criterion exists then they should all be employed and an average age reached. By combining the results of all of the different methods used the accuracy of the age estimate should greatly improve; this is referred to as multifactorial age estimation.

CONCLUSIONS

The multifactorial age estimation approach was used to estimate age for UMFC 141 at the time of death. Overall broad and narrow ranges were constructed from the results provided by the various methods applied to UMFC 141 to estimate age at the time of death.

<table>
<tr><th>Method</th><th>Broad Age Range</th><th>Narrow Age Range</th></tr>
<tr><td>Epiphysis Closure</td><td colspan="2">25</td></tr>
<tr><td>Todd and Lyon</td><td>20-82</td><td>28-30</td></tr>
<tr><td>Baker</td><td>19-89</td><td>24-74</td></tr>
<tr><td>Suture Site</td><td colspan="2">40-45</td></tr>
<tr><td>Skelton</td><td>14-45</td><td>20-35</td></tr>
<tr><td>Lovejoy</td><td colspan="2">24-35</td></tr>
<tr><td>Brothwell</td><td colspan="2">17-35</td></tr>
<tr><td>Sternal Rib Ends</td><td colspan="2">34.4-55.7</td></tr>
<tr><td>Pubic Symphysis</td><td colspan="2">24-45</td></tr>
<tr><td>Auricular Surface</td><td colspan="2">40-44</td></tr>
</table>

Table 18 Multifactorial age results from UMFC 141.

We know that this individual was at least 25 years of age because of the epiphysis closure method that gave the minimum age that UMFC 141 could be at the time of death. The broad range is estimated by using the lowest and highest possible ages. The lowest range possible is 25 years (Epiphysis closure). The highest age range was 89 from Baker's broad range. Thus, the broad range is 25-89 years of age at the time of death.

Estimating the narrow range is more difficult than estimating the broad range because you must determine the highest low and the lowest high age. However, due to the difference of the methods sometimes the technique gives inconclusive results. For example the highest low of UMFC 141 is 40 but the lowest high is 34.4. An age range of 40-35 is not possible. The technique must be modified to make up for overlaps such as the one previously given. The narrow range of UMFC 141 was taken as the highest low and the second lowest high. The highest low is 40 from the auricular surface method and the second lowest high is 44 also from the auricular surface. This gives a narrow age range of 40-44 years of age at the time of death. This age range is considered to be quite restrictive and it may be best to extend the narrow range. In this instance it may be more conductive to extend the highest low to 35 (from Brothwell's method), which would give an overall narrow range of 35-44 years of age. In conclusion, a wide range of 25-89 years of age and a narrow range of 35-44 years of age was estimated for UMFC 141.

RACE ESTIMATION

Probably the most difficult thing to establish when studying human skeletal remains is estimating the racial affiliation of the individual. Forensic anthropologists are taught to avoid any preconceived notions of race that would ultimately bias the observer and their observations. Although most forensic anthropologists would rather not subscribe to the idea of race, classifying human skeletal remains into 'racial' categories is usually demanded by law enforcement officials and the general public.

Forensic anthropologists classify human skeletal remains into three very broad categories. The first category is European, which tends to include peoples of European ancestry and Middle Eastern origin. The second category is African, which tends to include most people of African ancestry. The third category is Asian, which tends to include peoples of Native America, Asian, or of Pacific Island origin. Skelton stresses the importance of realizing that "these are very poor categories, poorly named, and not really reflective of the real worldwide pattern of human variation. However, they are still used by most authorities and we will reluctantly continue to use them ourselves" (Skelton 2003: 21). Within this paper the categories of European, African, and Asian will be used because of the familiarity of these broad terms. Morphological features and anthropomorphic measurements are two main ways to estimate ancestry from human skeletal material; however, a variety of methods exist within these two categories.

RACE ESTIAMTION FROM THE SKULL

Bass believes that one of the only areas to get an accurate estimate of racial ancestry comes from the skull (Bass 1995). The best that can be achieved with this method, according to Skelton (2003), is between 50 and 75 percent accuracy. Tables of morphological skull characteristics, similar to the one seen in Table 19, are the preferred method of determining if an individual exhibits one racial category or another. The technique is simple because all that needs to be done is to match as many traits from your specimen to those on a list. The racial category that receives the most matches to your specimen is the racial affiliation assigned to the individual being studied (Skelton 2003).

Bone/ Feature	**European**	**African**	**Asian**
Skull length	long to short	mostly long	long to short
Skull breadth	narrow to broad	narrow	broad
Skull height	high	low	medium
Cranial sutures	simple	simple	complex
Frontal bossing	females only	both sexes	females only
Face breadth	narrow	narrow	broad
Face height	high to medium	low to medium	high
Profile	orthognathic	strong prongnathism	moderate prognathism
Zygomatics	strong back taper	strong back taper	weak back taper
Zygomaxiallary suture	jagged or S-shaped	curved or S-shaped	angled
Interorbital distance	narrow	wide	medium
Orbit shape	angular to round	rectangular	rounded
Nasal orifice width	narrow	wide	medium
Nasal bones width	narrow	wide	medium
Nasal sill	sharp edge	smooth edge	intermediate
Chin	square, projecting	retreating	blunt, median

Ramus		narrow ascending	wide ascending
Palatal shape	parabolic	hyperbolic	elliptic
Palatal suture	Z-shape	arched	straight
Incisors	blade-form	blade-form	shovel-shaped
Dentition	crowded	not crowded	not crowded
Ruggedness	gracile	rugged	medium

Table 19 Race estimation from multiple skull characteristics (from Skelton 2003, Burns 1999, and Byers 2002).

UMFC 141 displayed characteristics from all three racial categories. Many of the characteristics that were attributed to UMFC 141 can be placed into more than one of the racial categories because there is substantial overlap among all three categories. The traits associated with African ancestry include zygomatics that posses a strong back taper and a smooth nasal sill. Zygomatics with strong back tapers are also associated with European ancestry. European characteristics that were exhibited by UMFC 141 include a long to short skull length, crowded dentition, and a parabolic palatal shape. The crowded dentition and parabolic palatal shape are only associated with European ancestry and the rest of the characteristics mentioned are associated with Asian ancestry. UMFC 141 was observed as having the following Asian characteristics: a broad skull breadth, a medium skull height, complex cranial sutures with Wormian bones, a broad facial breadth, a high facial height, moderate alveolar prognathism, an angled zygomaxillary suture, medium interorbital distance, rounded orbital shape, medium nasal orifice width, medium nasal bones width, a blunt median chin, a wide ascending ramus, a straight palatal suture, shovel shaped upper central incisors, and a fairly medium robustness.

Overall, UMFC 141 exhibited traits that were mainly indicative of Asian ancestry. There was some obvious overlap between the three ancestral categories but the common link between them all was Asian ancestry.

RACE ESTIMATION FROM THE SCAPULA AND SACRUM

In 1942, Hrdlička studied the measurements of the adult scapula in an attempt to estimate ancestry from those measurements. The measurements that are important are the maximum length, maximum breadth, and the scapular index. Hrdlička defined maximum length as "the distance between the superior and inferior angle" (A-B in figure 10) and the maximum breadth as being "secured by applying one of the points of the sliding [calipers] to the vertebral border and the other [end] to the middle of the posterior border of the glenoid cavity" (C-D in figure 10) (Hrdlička 1942: 375).

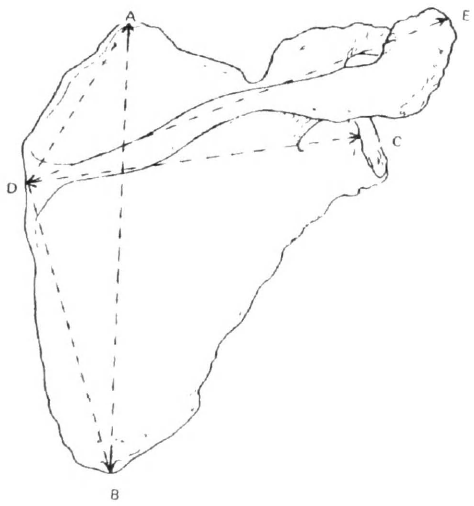


Figure 10 Landmarks for scapular measurement (from Bass 1995: 123).

To determine the scapular index the maximum breadth is multiplied by 100 and then divided by the maximum length. The formula is as follows:

$$\text{Scapular index} = \frac{\text{maximum breadth} \times 100}{\text{maximum length}}$$

The measurements that Hrdlička provided are shown in Table 20 below.

Group (M)	Number	Length total	Breadth total	Scapular index
Fuegian	35	160.2	99.0	61.8
Eskimo	4	157.0	97.2	61.9
Finn	72	165.5	102.5	62.4
New Caledonia	10	148.3	96.0	63.6
Europ. White	146	167.6	106.5	63.7
Old Peruv. Indian	55	158.3	101.7	64.2
Fuegian	7	153.8	98.8	64.3
N. W. Indian	10	165.2	104.8	64.3
Portuguese	37	159.2	102.1	64.4
Fuegian	4			64.8
French	78	159.2	103.7	65.2
U.S. White	70	164.0	107.0	65.3
Mex. Indian	9	158.0	104.0	65.5
Egyptian	6			65.9
Egyptian	11	157.8	104.2	66.5
Afr. Black	58	152.3	111.9	66.6
Amer. Negro	46	162.5	109.0	66.8
So. Mongol	20			66.9
So. Utah Indian	18	151.0	101.5	67.4
Pecos Indian	79	147.4	101.1	68.3
Melanesian	10	149.0	102.9	69.1
Lenape Indian	4	152.0	106.0	69.5
Pima and Pueblo	5	155.0	110.3	71.0
Negrillo	4	131.5	100.3	77.1

Table 20 Sample of scapular dimensions and indices arranged by scapular index from adult males; all measurements are in mm (from Hrdlička 1942: 381).

The maximum length of the left scapula of UMFC 141 was 150.88mm and the right scapula was 147.57mm. The maximum breadth of the left scapula of UMFC 141 was 97.52mm and the right scapula was 97.74mm. The scapular index for the left scapula was 64.63mm while the right scapular index was 66.23mm. The average of the two indices was calculated as 65.43mm and was used to estimate race for UMFC 141. The average of the indices fell directly between U.S. White (mean of 65.3mm) and Mexican Indian (mean of 65.5). Overall, the average of the indices fell closest to that of the Mexican Indian ancestry.

In 1920, Wilder studied measurements from the adult sacrum in an attempt to help estimate ancestry from those measurements. Wilder employed only six populations in his study. They include Negroes, Egyptians, Andamanese, Australians, Japanese, and Europeans. The measurements that are important include the maximum anterior breadth and height, as well as the sacral index. The maximum anterior height is the "measurement taken from the sacral promontory to the middle of the anterioinferior border of the last sacral vertebra (usually the fifth)" (A-B on figure 11) (Bass 1995: 113). The maximum anterior breadth "measures the greatest distance across the wings (lateral masses) of the first sacral vertebra" (C-D on figure 11) (Bass 1995: 113).

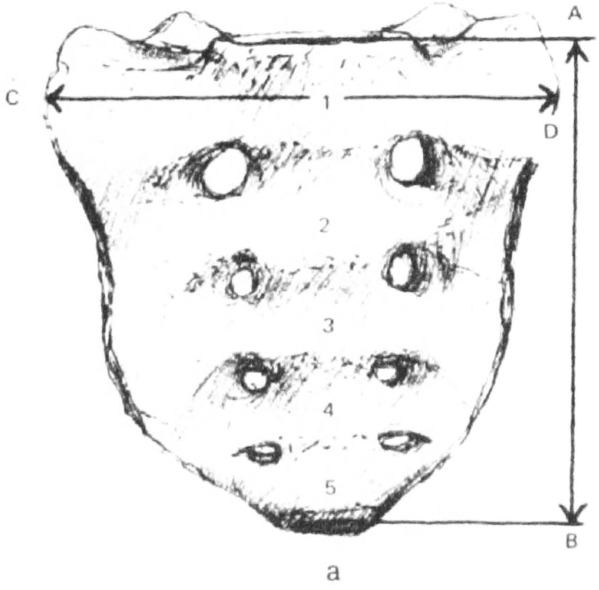


Figure 11 landmarks for sacral measurement (from Bass 1995: 114).

To determine the sacral index multiply the maximum anterior breadth by 100 and then divide by the maximum anterior height. The formula is as follows:

$$\text{Sacral index} = \frac{\text{maximum anterior breadth x } 100}{\text{maximum anterior height}}$$

Wilder's results are shown in table 21 below.

	Numbers	Mean (mm)
Negroes	33	91.4
Egyptians	7	94.3
Andamanese	22	94.8
Australians	14	100.2
Japanese	37	101.5
Europeans	63	102.5

Table 21 Racial indices of the sacral index for adult males (from Wilder 1920: 118).

The maximum anterior breadth of the sacrum of UMFC 141 was 107.18mm and the maximum anterior height was 113.98mm which equals to a sacral index of 94.03mm. A sacral index of 94.03mm put the remains of UMFC 141 near the Egyptian population.

RACE ESTIMATION FROM DISCRIMINANT FUNCTION ANALYSIS

In 1962, Giles and Elliot developed a method of estimating ancestry from discriminant function analysis that was similar to their sex estimation but more complex. They used eight cranial measurements to develop their discriminant function. Skelton stresses that this method "assumes that there are three populations (American White, American Black, and American Indian) into which all the people in the world can be divided... The number of discriminant functions needed to correctly identify the group membership of a person is always one less than the number of possible groups. Therefore, since there are two sexes [of male and female]... we need two functions to sort people as White, Black, or Indian [two functions for each race; one function for males and one for females; for a total of 6 functions]" (Skelton 2003: 22). This means that there needs to be two sets of formulae for each race that corresponds to the appropriate sex. The method is described below: (from Skelton 2003: 23).

1. Take the measurements necessary to use the functions. In this case they are g-op, eu-eu, ba-b, ba-n, zy-zy, ba-ids, ids-n, and al-al. All measurements are in mm.
2. Determine by some method whether the individual is female or male.
3. Choose which function or functions to use, based on the sex and possible population affinity of the individual.
4. Plug your measurements into the functions to get discriminant scores.
5. Look at the graphs (figure 12) and compare the discriminant score you obtained to the sectioning point to estimate the affinity of the individual.
6. Determine where your specimen falls on either the male or the female graph, based on its score from the White-Black function and the White-Indian Function.
7. Assign population affinity to the individual as American Black, American Indian, or American White, depending on which area of the graph the individual falls.

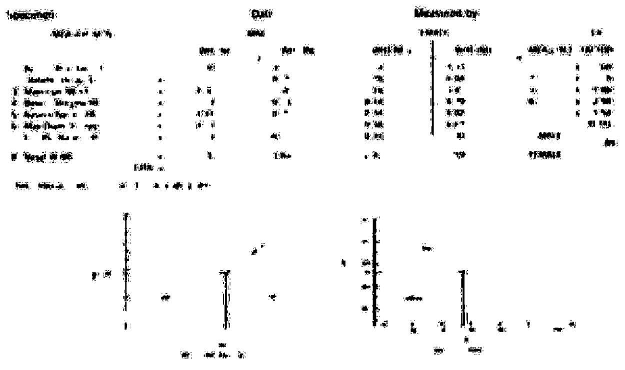


Figure 12 Worksheet for race identification from cranial measurements (Giles and Elliot 1962 as referenced in Bass 1995: 94).

Giles and Elliot's discriminant function analysis method was applied to UMFC 141 to estimate ancestry and the following results were obtained.

Ba-ids = 96mm
g-op = 179mm
eu-eu = 125mm
ba-b = 135mm
ba-n = 102mm
zy-zy = 131mm
n-ids = 71mm
al-al = 25mm

Wht/Neg (male)	Wht/Ind (male)
96 x 3.06 = 293.76mm	96 x .10 = 9.6mm
179 x 1.60 = 286.4mm	179 x -.25 = -44.75mm
125 x -1.90 = -237.5mm	125 x -1.56 = -195mm
135 x -1.79 = -241.65mm	135 x .73 = 98.55mm
102 x -4.41 = -449.82mm	102 x -.29 = -29.58mm
131 x -.10 = -13.1mm	131 x 1.75 = 229.25mm
71 x 2.59 – 183.89mm	71 x -.16 – -11.36mm
25 x 10.56 = 264mm	25 x -.84 = -21mm
Total = 85.98mm	Total = 35.71mm

The results from UMFC 141 fell between the American White and American Black graph but was further into the American Indian portion of the American White and American Indian graph.

RACE ESTIMATION FROM INTEROBITAL FEATURES

Gill developed a method using anthropomorphic measurements from three racial indices that can result in 90 percent accuracy (Gill 1984 as referenced in Bass 1995). The measurements are taken from the mid-facial area and include the maxillofrontal breadth, zygo-orbital, and alpha cord. These measurements are taken with a sinometer which is a coordinate caliper that has been modified to include a depth gauge. The maxillofrontal measurement is determined when the naso-maxillofrontal subtense (a depth measurement) is divided by the maxillofrontal breadth. Maxillofrontal breadth (number 1 in figure 13) is defined as "the intersection of the fronto-maxillary suture and anterior lacrimal crest, or the crest extended (medial edge of the eye orbit" (Bass 1995: 97). The naso-maxillofrontal subtense is "a subtense from the maxillofrontal points to the deepest point on the nasal bridge" (Bass 1995: 97). The zygo-orbital measurement is determined when the naso-zygo-orbital subtense (a depth measurement) is divided by the zygo-orbital breadth. Zygo-orbital (number 2 in figure 13) is defined as "the intersection of the orbital margin and the zygomaxillary suture" (Bass 1995: 97). The naso-zygoorbital subtense is "from the zygoorbital points to the deepest point along the nasal bridge" (Bass 1995: 97). The alpha cord measurement is determined when the naso-alpha subtense (a depth measurement) is divided by the alpha cord. The alpha cord (number 3 in figure 13) is defined as "the deepest point on the maxilla, left and right, on a tangent run between the naso-maxillary suture where it meets the nasal aperture, and zygoorbital" (Bass 1995: 97). The naso-alpha subtense is where "the alpha points to the deepest point on the nasal bridge" (Bass 1995: 97).

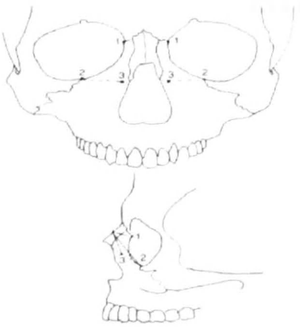


Figure 13 Landmarks for facial measurements (Gill 1984 as referenced in Bass 1995: 97).

This method was applied to UMFC 141 to estimate ancestry. The formulae are shown below.

Maxillofrontal index= naso-maxillofrontal subtense/ maxillofrontal breadth

Zygoorbital index= naso-zygoorbital subtense/ zygoorbital breadth

Alpha index= naso-aplha subtense/ alpha cord

The results from UMFC 141 are as follows.

Naso-maxillofrontal subtense= 12.8

Maxillofrontal breadth= 23.7

12.8/23.7 = .540

Maxillofrontal Index = 54

Naso-zygoorbital subtense= 19.8

Zygoorbital breadth= 52.12

19.8/52.12 = .379

Zygoorbital Index = 37.9

Naso-alpha subtense= 14.1

Alpha cord= 23.87

14.1/23.87 = .591

Alpha Index= 59.1

The maxillofrontal index fell into the White range indicated by Gill's graph (figure 14) but the zygoorbital index and the alpha index both fell into the Indian range.

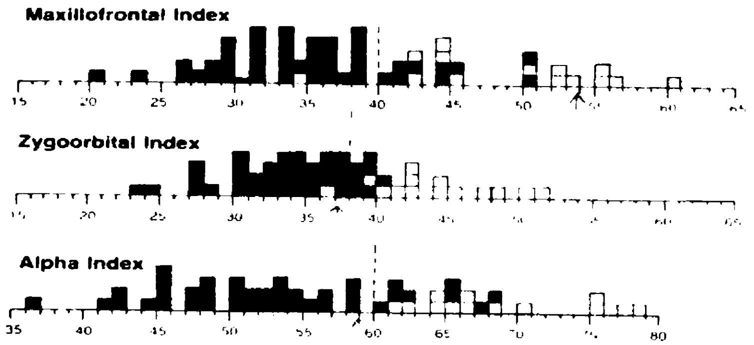


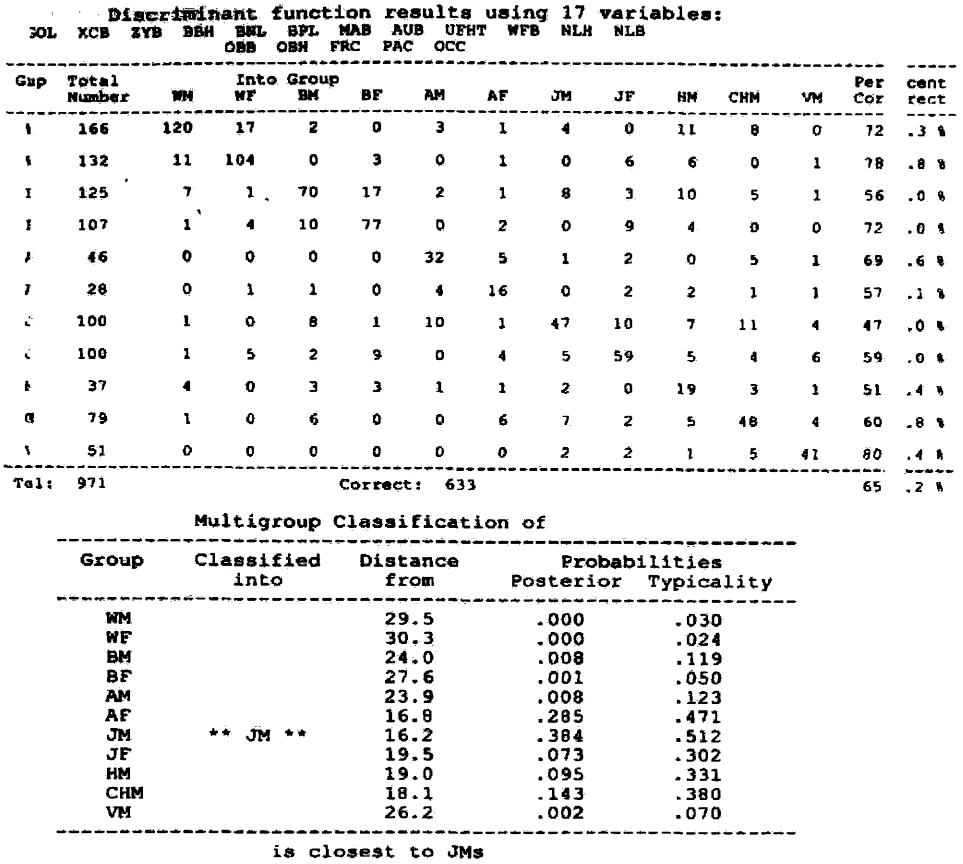
Figure 14 Indices for Indian-White racial differentiation (Gill 1984 as referenced in Bass 1995).

RACE ESTIMATION USING FORDISC

Steve Ousley and Richard Jantz, from the University of Tennessee at Knoxville, created a computer program called FORDISC to calculate measurements that were taken from the skull and estimate sex and ancestry by using discriminant function analysis. FORDISC uses two data sources, the University of Tennessee's Forensic Database and W.W. Howell's craniometric database. FORDISC has quite a few advantages over the Giles and Elliot discriminant function method because FORDISC can run with only a few measurements or more than Giles and Elliot require (Skelton 2003).

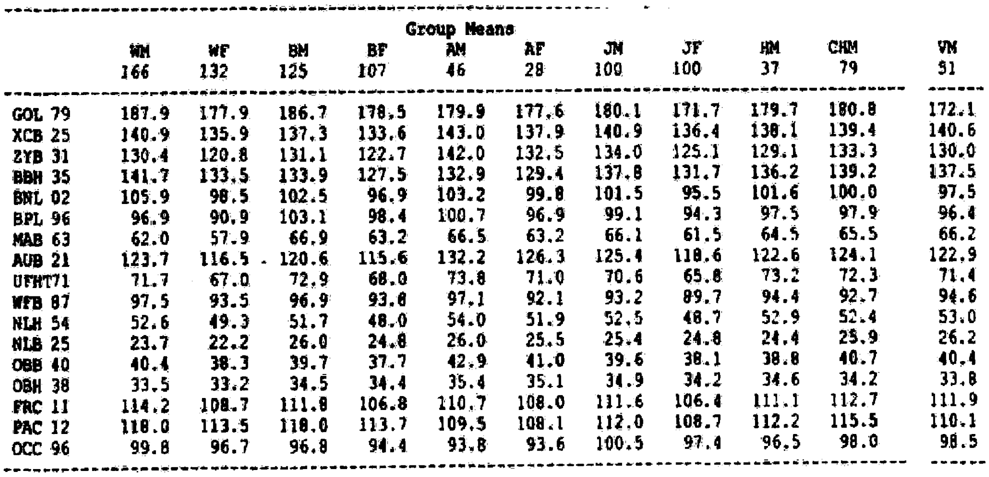
To begin using FORDISC, the cranial measurements that were taken must be put into the program. Once you select the type of analysis that you wish to run on your sample, the program begins to run the discriminant function analysis. FORDISC provides two statistics, the posterior probability and the typicality probabilities (Ousley and Jantz 1996). The posterior probability is the likelihood that the individual being studied may belong to a particular population in the analysis. The typicality probability reflects the probability of drawing an individual from a particular population that looks like the individual under study (Ousley and Jantz 1996). FORDISC like all discriminant function based methods will assign every individual to a group even when their group is not represented. Since this planet possesses a large number of populations, it is most unlikely that all groups are represented by the FORDISC program.

FORDISC was used to estimate ancestry from UMFC 141. Cranial measurements were taken and are listed in Appendix 1. The measurements were placed into FORDISC and the program provided the following results. The remains of UMFC 141 were run through both the Forensic Database and Howell's data set. Both data sets yielded similar results. The remains of UMFC 141 were classified as being a possible male of Japanese ancestry, with a .384 posterior probability and .512 typicality probability. When the data was run through Howell's data set, the remains of UMFC 141 were classified as being of possible Atayal ancestry, with a .495 posterior probability and a .134 typicality probability. According to Howell (1995), Atayal is an aboriginal tribe of Taiwan. Taiwan is an island in East Asia that lies east of China and south of Japan along the Tropic of Cancer. The discriminant function results of UMFC 141 from FORDISC can be seen in figures 15, 16, and 17.



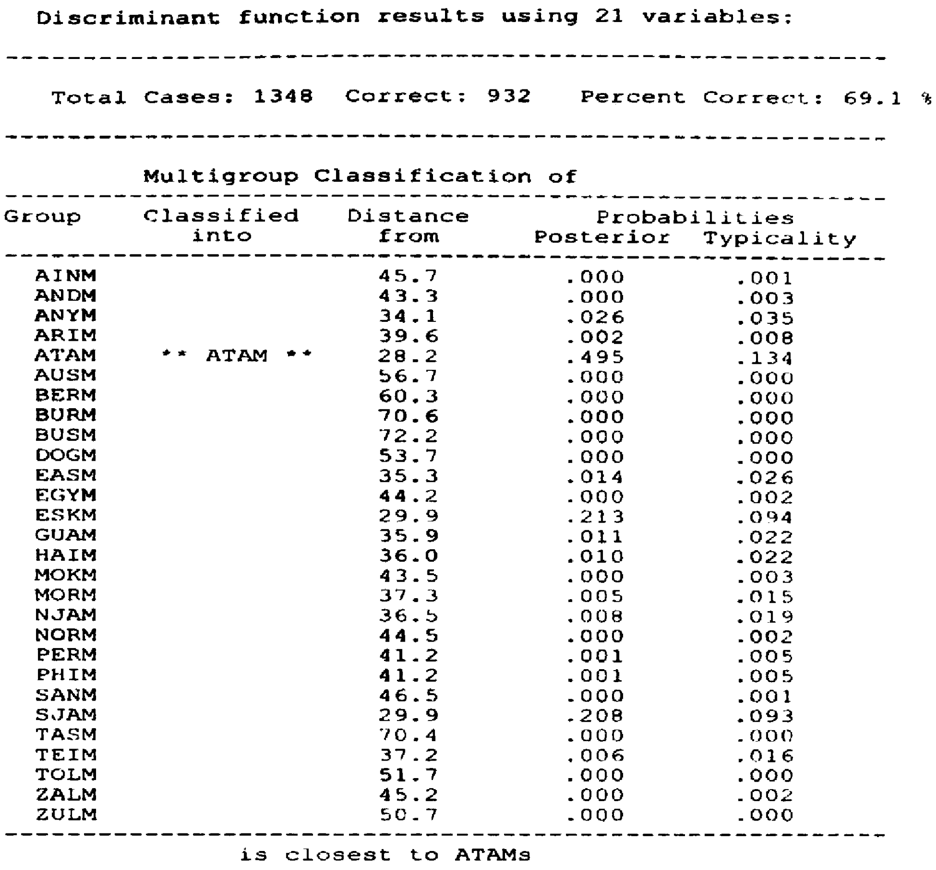
```
        Discriminant function results using 17 variables:
GOL  XCB  ZYB  BBH  BNL  BPL  MAB  AUB  UFHT  WFB  NLH  NLB
                         OBB  OBH  FRC  PAC  OCC
----------------------------------------------------------------------------------------   -----
Gp  Total               Into Group                                                    Per  cent
    Number      WM     WF     BM     BF     AM     AF     JM     JF     HM    CHM     VM  Cor  rect
----------------------------------------------------------------------------------------   -----
\    166       120     17      2      0      3      1      4      0     11      8      0   72  .3 %
\    132        11    104      0      3      0      1      0      6      6      0      1   78  .8 %
I    125         7      1     70     17      2      1      8      3     10      5      1   56  .0 %
I    107         1      4     10     77      0      2      0      9      4      0      0   72  .0 %
/     46         0      0      0      0     32      5      1      2      0      5      1   69  .6 %
/     28         0      1      1      0      4     16      0      2      2      1      1   57  .1 %
.    100         1      0      8      1     10      1     47     10      7     11      4   47  .0 %
.    100         1      5      2      9      0      4      5     59      5      4      6   59  .0 %
I     37         4      0      3      3      1      1      2      0     19      3      1   51  .4 %
(     79         1      0      6      0      0      6      7      2      5     48      4   60  .8 %
\     51         0      0      0      0      0      0      2      2      1      5     41   80  .4 %
----------------------------------------------------------------------------------------   -----
Tal:  971                       Correct:  633                                             65  .2 %

                   Multigroup Classification of
        ------------------------------------------------------------
          Group      Classified     Distance         Probabilities
                        into          from       Posterior  Typicality
        ------------------------------------------------------------
           WM                         29.5          .000        .030
           WF                         30.3          .000        .024
           BM                         24.0          .008        .119
           BF                         27.6          .001        .050
           AM                         23.9          .008        .123
           AF                         16.8          .285        .471
           JM        ** JM **         16.2          .384        .512
           JF                         19.5          .073        .302
           HM                         19.0          .095        .331
           CHM                        18.1          .143        .380
           VM                         26.2          .002        .070
        ------------------------------------------------------------
                        is closest to JMs
```

Figure 15 Results from FORDISC using Forensic Database



```
----------------------------------------------------------------------------------------   ------
                                        Group Means
            WM      WF      BM      BF      AM      AF      JM      JF      HM     CHM       VM
           166     132     125     107      46      28     100     100      37      79       51
----------------------------------------------------------------------------------------   ------
GOL 79   187.9   177.9   186.7   178.5   179.9   177.6   180.1   171.7   179.7   180.8    172.1
XCB 25   140.9   135.9   137.3   133.6   143.0   137.9   140.9   136.4   138.1   139.4    140.6
ZYB 31   130.4   120.8   131.1   122.7   142.0   132.5   134.0   125.1   129.1   133.3    130.0
BBH 35   141.7   133.5   133.9   127.5   132.9   129.4   137.8   131.7   136.2   139.2    137.5
BNL 02   105.9    98.5   102.5    96.9   103.2    99.8   101.5    95.5   101.6   100.0     97.5
BPL 96    96.9    90.9   103.1    98.4   100.7    96.9    99.1    94.3    97.5    97.9     96.4
MAB 63    62.0    57.9    66.9    63.2    66.5    63.2    66.1    61.5    64.5    65.5     66.2
AUB 21   123.7   116.5 . 120.6   115.6   132.2   126.3   125.4   118.6   122.6   124.1    122.9
UFHT71    71.7    67.0    72.9    68.0    73.8    71.0    70.6    65.8    73.2    72.3     71.4
WFB 87    97.5    93.5    96.9    93.8    97.1    92.1    93.2    89.7    94.4    92.7     94.6
NLH 54    52.6    49.3    51.7    48.0    54.0    51.9    52.5    48.7    52.9    52.4     53.0
NLB 25    23.7    22.2    26.0    24.8    26.0    25.5    25.4    24.8    24.4    25.9     26.2
OBB 40    40.4    38.3    39.7    37.7    42.9    41.0    39.6    38.1    38.8    40.7     40.4
OBH 38    33.5    33.2    34.5    34.4    35.4    35.1    34.9    34.2    34.6    34.2     33.8
FRC 11   114.2   108.7   111.8   106.8   110.7   108.0   111.6   106.4   111.1   112.7    111.9
PAC 12   118.0   113.5   118.0   113.7   109.5   108.1   112.0   108.7   112.2   115.5    110.1
OCC 96    99.8    96.7    96.8    94.4    93.8    93.6   100.5    97.4    96.5    98.0     98.5
----------------------------------------------------------------------------------------   ------
```

Figure 16 Cranial Measurements and Group Means



```
Discriminant function results using 21 variables:
-----------------------------------------------------------
 Total Cases: 1348  Correct: 932   Percent Correct: 69.1 %
-----------------------------------------------------------
          Multigroup Classification of
-----------------------------------------------------------
Group     Classified    Distance        Probabilities
             into         from      Posterior  Typicality
-----------------------------------------------------------
  AINM                    45.7         .000        .001
  ANDM                    43.3         .000        .003
  ANYM                    34.1         .026        .035
  ARIM                    39.6         .002        .008
  ATAM      ** ATAM **    28.2         .495        .134
  AUSM                    56.7         .000        .000
  BERM                    60.3         .000        .000
  BURM                    70.6         .000        .000
  BUSM                    72.2         .000        .000
  DOGM                    53.7         .000        .000
  EASM                    35.3         .014        .026
  EGYM                    44.2         .000        .002
  ESKM                    29.9         .213        .094
  GUAM                    35.9         .011        .022
  HAIM                    36.0         .010        .022
  MOKM                    43.5         .000        .003
  MORM                    37.3         .005        .015
  NJAM                    36.5         .008        .019
  NORM                    44.5         .000        .002
  PERM                    41.2         .001        .005
  PHIM                    41.2         .001        .005
  SANM                    46.5         .000        .001
  SJAM                    29.9         .208        .093
  TASM                    70.4         .000        .000
  TEIM                    37.2         .006        .016
  TOLM                    51.7         .000        .000
  ZALM                    45.2         .000        .002
  ZULM                    50.7         .000        .000
-----------------------------------------------------------
               is closest to ATAMs
```

Figure 17 Results from Howell’s data set, males only

CONCLUSIONS

All of the methods described above put the remains of UMFC 141 as being of Asian descent. Wilder’s sacral index placed the remains into the Egyptian category, which is quite unlikely because the people of Egypt may demonstrate European and/or African characteristics.

The method of determining race from the femur could not be applied because it required tools that were unavailable.

A REVIEW OF LITERATURE ON DETERMINING STATURE FROM LONG BONES: PAST AND PRESENT

Forensic anthropologists are interested in the human skeleton for a variety of reasons; the most important of which is to provide information necessary to assist law enforcement personnel in properly identifying human skeletal remains. Forensic anthropologists are interested in estimating age, sex, racial affiliation, trauma, pathology, weight, and height. The miscalculation of any one of these criteria can lead an investigation in the wrong direction and may ultimately lead to an inaccurate identification of the human remains. Stature is still considered to be an integral part of properly identifying human skeletal remains. Trotter (1970) stated that stature is an important identifying characteristic of an individual.

Stature is considered to be "one of the [most] recurrent problems in physical anthropology" (Genovés 1967: 67) and one of the most complex problems to solve. Prior to stature being estimated both the sex and racial affiliation of the individual must first be known. Genovés (1967) recognized the importance of using a stature estimation formula derived from the same population as the person whose stature is being estimated.

Interest in estimating stature can be traced back to the late 19th century. In 1888, Rollet published the world's first formal tables for estimating stature (Krogman 1962). Rollet studied the stature and lengths of 50 French male and 50 French female cadaver long bones, ranging in age from 24 to 99. Rollet's methods for measurement, the individual measurements observed, as well as the tables used for estimation of stature were meticulously recorded for later use (Trotter and Gleser 1952). Rollet's raw data was later used in analyses by Manouvrier, Pearson, and Stevenson.

There were fundamental differences between Rollet's and Manouvrier's data sets. Rollet "determined average lengths of a given long bone from those who presented the same stature" (Trotter and Gleser 1952: 464), while Manouvrier "determined the average stature of individuals who presented the same length for a given bone" (Krogman 1962: 154). In 1899, Karl Pearson turned Rollet's data from bones of the right side into regression formulae and disregarded Manouvrier's concern about the relationship between advanced age and stature. Pearson believed that stature stoop due to advanced age does not leave very marked or observable characteristics (Krogman 1962). In 1929, Stevenson tried to use Pearson's formulae to compare Rollet's French data set to his modern Northern Chinese male data set and found that formulae developed for one population fails to yield satisfactory results for another population (Trotter and Gleser 1952).

The usefulness of stature estimates for identifying individuals did not become abundantly clear until the passing of the United States Repatriation Program in 1944 (Trotter and Gleser 1952). This program was set up to help identify American war causalities from overseas and to bring them home to be reburied properly. Stature was an integral part of this program because each man enlisted in the armed forces had his height recorded immediately upon enlistment. Dupertuis and Hadden (1951) could not believe that the formulae developed by Pearson had been in use for the last half century. They became two of the first observers to address the problems associated with Pearson's regression formulae because they realized that the Rollet data and Pearson formulae were based on a fairly short population and would therefore be inadequate for taller populations (Dupertuis and Hadden 1951). Dupertuis and Hadden thought it would be advisable to create new formulae for taller European and African populations (Dupertuis and Hadden 1951).

Mildred Trotter and Goldine Gleser became two of the first individuals to address the problem of calculating a new set of formulae for taller populations. In1952 and 1958, Trotter and Gleser published studies of American military dead and the Terry Anatomical Collection to help generate new formulae for taller White and Negro populations. First, in 1952, they published their studies of male American military World War II causalities from the Pacific zone and male and female specimens from the Terry Anatomical Collection. Both samples consisted only of American White and Negro races with ages of at least 18 years of age. The ages of the World War II sample ranged from late teens to early twenties while the ages of the Terry Collection ranged from 19 to 99 years of age (Trotter and Gleser 1952). Both the right and left upper and lower limb bones were measured and then the average of the pair was used to estimate the stature of the individual and to help aid in the creation of the formulae. The Terry collection was utilized so the World War II sample could be compared against it and the formulae for females of both races could be revised (Trotter and Gleser 1952). The results showed that the formulae were nearly identical to each other.

In 1958, Trotter and Gleser received a second chance to study stature with the end of the Korean War (1950-1953). With this event came an unusual combination of data. Like in their previous study with the World War II casualties, they had access to stature data that had been recorded from the military personnel of the armed forces as they enlisted and at their time of death (Trotter and Gleser 1958). Trotter and Gleser used their previous study of the World War II casualties for "validation and refinement" of the formulae that they had already produced. Unlike the previous study, the averages of the upper and lower limb bones were not taken but were treated as isolated cases. Furthermore, this study utilized not only White and Negro populations but American Mexican and Puerto Rican populations as well. Trotter and Gleser found that when the World War II and Korean War studies were compared the equations for radii and ulnae and the male results from the two collections were nearly equivalent to one another (Trotter and Gleser 1958). The tibia formulae of the Korean study showed some inconsistencies with that of the World War II study. The average tibia length in the Korean study was significantly longer than the World War II study. Trotter and Gleser believed that "such a difference could result from…variation in the technique of measuring the tibia" and that "errors are random and thus have not biased the averages of stature and bone lengths" (Trotter and Gleser 1958: 82). The Trotter and Gleser formulae are still the best stature estimations available and are still used abundantly today. Nevertheless, in recent years the formulae of Trotter and Gleser have fallen under attack, most notably by Richard Jantz.

In 1992, Richard Jantz proposed a modification to the Trotter and Gleser formulae for females. Jantz wanted to implement this modification because the female formulae had not seen new data since the data was collected from the Terry collection (Jantz 1992). Jantz compared the long bone lengths of modern female forensic cases to those used by Trotter and Gleser and found that the femur and tibia formulae for whites differ by an average of 3cm (Jantz 1992). Jantz employed the Forensic Anthropological Data Bank at the University of Tennessee because it contained the following information concerning samples; long bone lengths, age, sex, race, and stature (Jantz 1992). The Terry

Anatomical Collection was insignificant to use to study modern female populations because the birth years of the collection are mainly from the mid-19th century, which was "a time when American statures were lower than at any other time since 1710" (Jantz 1993: 762). Jantz believed that the differences of the tibia stature estimations "implied the existence of a change in the proportions in whites, the tibia being relatively longer in modern individuals" (Jantz 1992: 1231). The formulae that Trotter and Gleser created for black females, according to Jantz, did not warrant adjustment like the white female formulae (Jantz 1992).

Eugene Giles, on the other hand, had "very serious reservations" about Jantz's proposed modifications to the Trotter and Gleser formulae (Giles 1993). Giles stated that "for 40 years Trotter and Gleser's set of linear regression equations…have provided American forensic anthropologists a standard method for estimating the living stature of blacks and whites" (Giles 1993: 758). Giles took his critique further when he made comments pertaining to the pitfalls of modifying such a well used and trusted system of estimating stature.

> I think professional forensic anthropologists would be better advised to continue using the set of consistent and defensible regression formulations Trotter and Gleser have provided us rather than begin having to pick and choose, by race, sex, and bone, from among the old Trotter and Gleser and new, potentially fluctuating databases and then quite likely having to defend the statistical merit of their choice in court (Giles 1993: 759-760).

Jantz responded to Giles by pointing out that Trotter and Gleser mentioned in their studies that with the discovery of new secular trends new formulae need to be created to fit the changing model (Jantz 1993). Jantz continues his defense that the Trotter and Gleser formulae are not "consistent and defensible" for modern populations because the formulae had not been tested against modern populations until recently and thus it would be problematic to use the Terry collection as a reference sample because the collection has not been properly tested and modified for modern populations (Jantz 1993).

In 1995, Jantz furthered his study of the Trotter and Gleser formulae by comparing the measurements from the Terry Collection and the World War II study of Trotter and Gleser with measurements that were taken by himself and his colleagues. The results of this comparison showed that Trotter consistently mis-measured the tibia because the malleolus had been omitted from the measurement (Jantz *et al.* 1995). The measurements of Trotter and Gleser were 10-12mm shorter than the ones that were taken for Jantz's study (the tibiae were properly measured with the malleolus included in the measurement) which averaged out to be around 2.5 to 3.0cm shorter in stature estimations. Jantz and his colleagues commented that these differences, though not great, could still be a confusing factor in population studies. Jantz suggests always utilizing the femur over the tibia whenever possible. If the tibia is used, measure it like Trotter and omit the malleolus from the measurement or apply the suggested modifications that are provided so that the tibia can be measured properly with the malleolus included in the measurements (Jantz *et al.* 1995).

The studies of taller white and black populations were not the only studies present during the time that Trotter and Gleser were dominating the field of estimating stature. In 1967, Santiago Genovés completed a study of the proportionality of long bones and their relationship to stature among Mesoamericans. Genovés measured 235 cadavers (176 males and 59 females) of a pre-hispanic population from Coixtlahuaca, the state of Oaxaca, Mexico. This study was undertaken, according to Genovés, because the only information that was known about Mesoamerican populations came from the 1958 study of Korean war dead by Trotter and Gleser when they included "Mexican" and "Asian" soldiers that had died during the war (Genovés 1967). The "Asian" soldiers were considered to be an add mixture of Japanese, Hawaiians, Filipinos, Amerindians, and others, while the Mexican mean (168.25cm) was well above the normal values of Mesoamericans (Genovés 1967). Genovés developed regression formulae that would be suitable to use on shorter populations, particularly those of Mexican descent.

Other studies concerning the estimation of stature were being undertaken in more unorthodox manners. In 1978, Jonathan Musgrave and Narendra Harneja decided to study the relationship between metacarpal length and stature. They studied adult patients of both sexes at the Accident Department of the Bristol Royal Infirmary, in Bristol, England, that possessed minor hand injuries. They measured the living stature of each individual upon admittance as well as the metacarpals of 53 male left, 67 male right, 20 female left, and 26 female right hands. The ages of these individuals ranged from 18 to 87 years of age for males and 17 to 77 years of age for females (Musgrave and Harneja 1978). When the regression formulae were developed and applied they concluded that the formulae they developed "can be regarded as useful only if they yield estimates of living stature comparable to those obtained by more orthodox methods" (Musgrave and Harneja 1978: 115). The results yielded a difference of three percent between metacarpal length and that of long bone length. Despite the three percent difference, Meadows and Jantz undertook a study of metacarpal length to determine stature in 1995.

Meadows and Jantz developed a set of regression formulae from the metacarpals of 267 individuals from two samples. 212 individuals came from the Terry Collection and consisted of 53 black males, 56 white males, 55 black females, and 48 white females.

These individuals were chosen because their demographics and stature were known. The remaining 55 individuals consisted of 30 modern black males and 25 modern white males from the Regional Forensic Center in Memphis, Tennessee. This modern sample was utilized as a test sample to test the new regression formulae and to look for changes that may have been caused by secular trends (Meadows and Jantz 1992). The results of this study indicated that "stature estimates from metacarpals are to be preferred to those based on long bone fragments... [However,] differences between the Terry long bone dimensions and... modern cases have been documented, and Terry-based standards have been shown to be biased in certain instances" (Meadows and Jantz 1992: 153).

Regardless of the differences between long bone length and metacarpal length, Steve Byers, Kaoru Akoshima, and Bryan Curran decided to develop a study on the value of metatarsal length to estimate stature in 1989. They studied 130 macerated and dried skeletons that had known demographics with the exception of 11 individuals. 66 individuals came from the Terry Collection and the remaining 64 came from the University of New Mexico's Maxwell Museum of Anthropology (Byers *et al.* 1989). The average of the right and left bones were taken and regression formulae were developed as in the previous studies. They concluded that "the errors of estimating stature from metatarsals are greater than those estimates of stature from long bones; however, they are approximately the same size as those for fragmentary long bones and metacarpals" (Byers *et al.* 1989: 279).

In spite of the numerous studies that have taken place over the last few years, the formulae developed by Trotter and Gleser (with a few modifications) are still considered to be the best method for estimating stature in modern individuals. William Bass, a noted forensic anthropologist, believes that the studies by Trotter and Gleser are the most reliable and that they are still the most used formulae for estimating living stature from the skeletal material (Bass 1995). Despite the faith that has been placed in the Trotter and Gleser formulae, caution must always be practiced when estimating stature. The observer must always measure in the same manner and have a fairly good estimate of racial affinity, sex, and age before estimation can even begin, as well making sure the proper formula is chosen based upon the knowledge at hand.

STATURE AND WEIGHT ESTIMATION

The most reliable way to estimate stature for an individual is long bone length. According to Bass, the formulae provided by the studies of Trotter and Gleser (1952, 1958) are the most reliable (Bass 1995). Suitable bones for estimating stature are the humeri, ulnae, radii, metacarpals, femora, tibiae, fibulae, and metatarsals. Once the maximum length of each bone is taken using an osteometric board (the ideal instrument for measuring maximum length), the measurements are plugged into the appropriate formulae for the person's race and sex or compared to an appropriate chart for the person's sex and race.

The stature of UMFC 141 was estimated using the measurements of the left and right humeri, left and right ulnae, left and right radii, the left and right femora, the left and right tibiae, and the left and right fibulae. The results are as follows:

Humerus=285mm(left), 290mm(right)
Ulna=244mm(left, 246mm(right)
Radius=221mm(left), 220(right)
Femur=399mm(left), 395(right)
Tibia=336mm(left), 335mm(right)
Fibula=323mm(left), 316mm(right)

UMFC 141 was most probably a male of predominately Asian ancestry therefore the bone lengths given above were plugged into the formulae given by Trotter and Gleser (1958). The average of both the left and right sides were taken instead of dealing with each bone individually. Trotter and Gleser's formulae for stature estimation of male individuals with Asian ancestry is shown below in figure 18.

Figure 18 Stature formulae for adult Asian males (From Trotter and Gleser 1958)

The stature results from using the above formulae are as follows:

1.22 (39.7 + 31.95) + 70.24= **stature from femur and fibula**
1.22 (71.65) + 70.24= 87.41 + 70.24= 157.65±3.18cm (154.47-160.83) = 60.81-63.32 inches = 5 feet 1 inch to 5 feet 3 inches

1.22 (39.7 + 33.55) + 70.37= **stature from femur and tibia**
1.22 (73.25) + 70.37= 89.67 + 70.37= 160.04±3.24cm (156.8-163.28) = 61.73-64.28 inches = 5 feet 2 inches to 5 feet 4 inches

2.40 (31.95) + 80.56= **stature from fibula**
76.68 + 80.56= 157.24±3.24cm (154-160.48) = 60.63- 63.18 inches = 5 feet 1 inch to 5 feet 3 inches

2.39 (33.55) + 81.45= **stature from tibia**
80.18 + 81.45= 161.63±3.27cm (158.36- 164.90) = 62.35- 64.92 inches = 5 feet 2 inches to 5 feet 5 inches

2.15 (39.7) + 72.57= **stature from femur**
85.36 + 72.57= 157.93±3.80cm (154.13-161.73) = 60.68- 63.67 inches= 5 feet 1 inch to 5 feet 4 inches

1.68 (28.75 + 24.5) + 71.18= **stature from humerus and ulna**
1.68(53.25) + 71.18= 89.46 + 71.18= 160.64±4.14 (156.50- 164.78) = 61.61- 64.87 inches= 5 feet 2 inches to 5 feet 5 inches

1.67 (28.75 + 22.05) + 74.83= **stature from humerus and radius**
1.67(50.8) + 74.83= 84.84 + 74.83= 159.67±4.16cm (155.51- 163.83) = 61.22- 64.5 inches= 5 feet 1 inch to 5 feet 5 inches

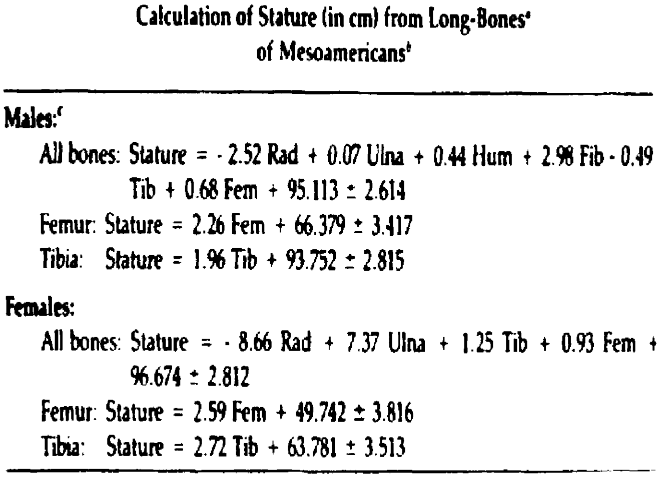
2.68 (28.75) + 83.19= **stature from humerus**
77.05 + 83.19= 160.24±4.25cm (155.99- 164.49) = 61.41-64.76 inches= 5 feet 1 inch to 5 feet 5 inches

3.54 (22.05) + 82.00= **stature from radius**
78.06 + 82.00= 160.06±4.60cm (155.46-164.66) = 61.20- 64.83 inches= 5 feet 1 inch to 5 feet 5 inches

3.48 (24.5) + 77.45= **stature from ulna**
85.26 + 77.45= 162.71±4.66cm (158.05- 167.37) = 62.22- 65.89 inches= 5 feet 2 inches to 5 feet 6 inches

The results from the above formulae indicate a stature range of 60.63- 65.89inches, which is approximately 5 feet 1 inch to 5 feet 6 inches, at the time of death.

Stature for UMFC 141 was also calculated using Genovés' (1967) formulae from Mesoamerican skeletal remains. Bass felt compelled to point out that Genovés' data was significantly different than all others that existed primarily because he conducted his study on a very short population. Body proportions of short people are drastically different from the proportions of taller populations and would thus require different regression formulae (Bass 1995). The stature formulae developed by Genovés is illustrated below in figure 19.



Calculation of Stature (in cm) from Long-Bones[a] of Mesoamericans[b]

Males:[c]

All bones: Stature = - 2.52 Rad + 0.07 Ulna + 0.44 Hum + 2.98 Fib - 0.49 Tib + 0.68 Fem + 95.113 ± 2.614
Femur: Stature = 2.26 Fem + 66.379 ± 3.417
Tibia: Stature = 1.96 Tib + 93.752 ± 2.815

Females:

All bones: Stature = - 8.66 Rad + 7.37 Ulna + 1.25 Tib + 0.93 Fem + 96.674 ± 2.812
Femur: Stature = 2.59 Fem + 49.742 ± 3.816
Tibia: Stature = 2.72 Tib + 63.781 ± 3.513

Figure19 Stature formulae for Mesoamerican long bones (From Genovés 1967)

The results from applying these formulae to UMFC 141 are as follows:

-2.52 (22.05) – 0.07 (24.5) + 0.44 (28.75) + 2.98 (31.95) – 0.49 (33.55) + 0.68 (39.7) + 95.113= **stature from all bones**
-55.57 – 1.72 + 12.65 + 95.21 – 16.44 + 26.99 + 95.113= 156.23± 2.614cm (153.62-158.84) = 60.48- 62.54 inches = 5 feet to 5 feet 3 inches

2.26 (39.7) + 66.379= **stature from femur**
89.72 + 66.379= 156.10± 3.417cm (152.68- 159.52) = 60.11- 62.80 inches= 5 feet to 5 feet 3 inches

1.96 (33.55) + 93.752= **stature from tibia**
65.76 + 93.752= 159.51± 2.815cm (156.70- 162.33) = 61.69- 63.91 inches= 5 feet 2 inches to 5 feet 4 inches

The results that this method yielded are very similar to those of the Trotter and Gleser formulae. Genovés's method indicates a stature range of 60.11- 63.91inches, which is approximately 5 feet to 5 feet 4 inches, at the time of death.

It should be stated that both the left and right tibiae and fibulae were broken premortem along the midshaft which may potentially skew stature estimations. The stature ranges that were generated from the formulae of Trotter and Gleser and Genovés indicate an acceptable range of height even with the trauma suffered by the lower limbs. The overall range between these two formulae for stature is 5 feet to 5 feet 6 inches. UMFC 141 possessed a medium to rugged build and could very well have been at least 5 feet 6 inches tall at the time of death. A median stature range of 5 feet 2 inches and 5 feet 4 inches is probably closer to the actual height of this individual at the time of death.

WEIGHT

One of the most difficult aspects to estimate from the human skeleton is that of weight and robusticity because of the variability of these phenomena from person to person. It is possible to estimate weight from charts found in doctor's offices but they are intended to demonstrate what people should weigh and not what they really do weigh. It has also been found that "recent studies have shown that these charts underestimate ideal weights for people in modern western society by about 20% [and] it is only rarely that age is dealt with satisfactorily by these charts" (Skelton 2003: 41). The chart shown in table 22 illustrates the height-weight for males from the Metropolitan Life Insurance Company. The chart has been divided into gracile, medium and robust.

Stature		**Gracile**	**Medium**	**Robust**
Inches	cm			
5'2	157	116±17	124±19	133±20
5'3	160	119±18	127±19	136±20
5'4	163	122±18	130±20	140±21
5'5	165	125±19	133±20	144±22
5'6	168	129±19	137±21	148±22
5'7	170	133±20	141±21	152±23
5'8	173	137±21	145±22	157±24
5'9	175	141±21	149±22	161±24
5'10	178	145±22	153±23	165±25
5'11	180	149±22	157±24	169±25
6'0	183	153±23	162±24	174±26
6'1	185	157±24	167±25	179±27
6'2	188	162±24	171±26	183±27
6'3	191	166±25	176±26	188±28
6'4	193	169±25	181±27	193±29

Table 22 Metropolitan Life Insurance height/ weight chart for adult Males (from Skelton 2003).

A median stature range of 5 feet 2 inches to 5 feet 4 inches was used to estimate weight for UMFC 141. The remains probably belong to an individual with medium robusticity because the bones are not overly small and gracile or overly large and robust. Based on the chart above the weight of this individual was probably between 124±19 pounds to 130±20 pounds at the time of death. When the weight is adjusted for age the weight is probably closer to that of 130.2±25.2 – 136.2±26.2 pounds.

HANDEDNESS ESTIMATION

Determining handedness establishes whether the individual being assessed was right handed, left handed, or ambidextrous. Roughly 90 percent of the human population is right handed while the remaining 10 percent are left handed or ambidextrous (Burns 1999). The methods for determining handedness are imprecise for skeletal material. According to Burns, "one thing is certain-the majority of skeletons are asymmetrical... it is generally accepted among anthropologists that the dominant arm tends to be longer" (Burns 1999:157). Burns suggests that more information is obtained from the scapula and humerus before estimating handedness.

The scapula can be studied for differences in use patterns, especially around the glenoid fossa. The dominant scapula will tend to show a dorsal bevel around the glenoid fossa while the non-dominant side will tend to show a "simple osteoarthritic rim on the dorsal margin of the glenoid fossa" (Burns 1999: 157). Stewart's method can be used to help visualize the glenoid bevel or osteoarthritic rim by simply drawing the flat side of a piece of chalk or pencil lead across the surface of the glenoid fossa and the scapulae can then be compared by whether or not the bevel outside of the dorsal rim of the glenoid fossa is present or not (figure 20).

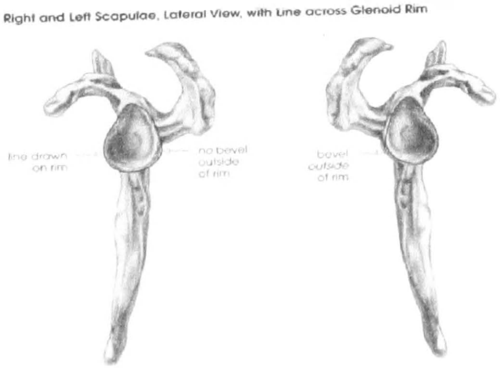


Figure 20 Stewart's method for estimating handedness (Burns 1999: 158).

If one arm is beveled and the other is not than that individual probably used the beveled arm more and therefore the arm that has experienced the most use is primarily the dominant arm and, by inference, the dominant hand (Burns 1999).

The humerus can be compared for differences in muscle attachments, such as the deltoid tuberosity (see figure 21). The dominant side will reveal a somewhat larger attachment area than the non-dominant side.

Figure 21 Anterior view of left humerus (Burns 1999: 69).

Osteoarthritic changes may also be examined in the elbow area of the humerus and may be a sign of increased use on one side over the other (Burns 1999).

The maximum length of the right humerus measured 289mm, the right radius measured 167mm, the right ulna measured 168mm while the maximum length of the left humerus measured 285mm, the left radius 163mm, and the left ulna measured 167mm. The right humerus also exhibited larger muscle attachments of the deltoid tuberosity than that of the left side. From this method of asymmetry the right arm is dominant because it is longer than the left side and has larger muscle attachments. Using Stewart's method it was shown that the right arm is dominant because of the dorsal bevel on the right side and the absence of a bevel on the left side. Both of these methods indicate that this individual was probably right handed.

PATHOLOGY AND TRAUMA

Determining the possible cause of death of an individual is not what Steven Byers calls forensic anthropologist's "legal responsibility" but believes they "should provide information medical examiners or coroners can use to...make determinations... [concerning]...the cause and manner of death" (Byers 2002: 254). Forensic anthropologists do not hold medical degrees, but rather are professionally trained in the analysis of human skeletal remains. Forensic anthropologists can determine if an injury occurred premortem (before death), perimortem (around the time of death), or postmortem (after death) to help determine if the injury or pathology may have contributed to the death of an individual. Forensic anthropologists may use descriptive terms such as defect, pitting, deterioration, and lipping.

A GENERAL OVERVIEW OF PATHOLOGY

There are many types of pathological conditions and they all vary in their contributing causes. Donald J. Ortner and Walter G.J. Putschar name three basic types of pathological conditions; lytic, proliferative, and deformative (Ortner and Putschar 1981). Lytic lesions are associated with the loss of bone by means of erosion and/ or destruction. This erosion and destruction occurs among the trabecular and cortical bone in the form of small pores to large caultations (Byers 2002). Anemia is the most common type of lytic lesion. Anemia is caused by low levels of iron in the hemoglobin of red blood cells, this causes the production of more red blood cells and the diploe of the skull expands to make room for the increase. Cribra orbitalia and porotic hyperostosis are two common types of anemia, besides that of sickle cell anemia. Anemia can be inherited, such as sickle cell, or due to general malnutrition (Byers 2002).

Proliferative lesions are associated with excess bone that has been laid down at various portions of the skeleton, the sizes of the lesions range from small exostoses to large outgrowths (Byers 2002). The most common type of proliferative lesion occurs on the vertebral body in the form of osteophytes, which have been linked to osteoarthritis.

Deformative lesions are lesions that have abnormal contours or shapes. The most well known type of deformative lesion is rickets, a vitamin D deficiency in children that causes the long bones to bow anteroposteriorly or mediolaterally to some extent (Byers 2002). Deformative lesions have two types of origins, environmental and congenital. Environmental includes things that affect the skeleton due to geography, occupation or even age. Nutritional diseases (such as rickets) are also included under environmental. Congenital refers to defects or genetic disorders that an individual is born with as opposed to contracting in some manner (Ortner and Putschar 1981).

A GENERAL OVERVIEW OF TRAUMA

Trauma has been most associated with the cause and manner of death. According to Steve Byers "when there is evidence of traumatic injury to human bone, forensic anthropologists attempt to identify the nature of the trauma…with the intent of gathering information pertaining to the cause and manner of death" (Byers 2002: 1). Trauma can be defined as the "pathological category defined as an injury caused to living tissue by an outside force" (Byers 2002: 254). Forensic anthropologists are interested in how trauma can affect bone. In order to understand the nature of the trauma the forensic anthropologists must be able to distinguish between a whole horde of conditions. If the trauma was a fracture, what type of fracture was it? Was the trauma caused by blunt force, sharp force, projectile or miscellaneous? Did the injury occur premortem, perimortem, or postmortem? The forensic anthropologist attempts to answer these questions while trying to provide enough information for the Medical Examiner or Coroner to determine if the individual's death was homicide, suicide, accidental, natural or unknown.

"When sufficient force is applied to bone, a break will occur. If this break travels completely through the bone it is called a fracture...an incomplete break is an infraction" (Byers 2002: 258). Fractures can vary from complete, hinged, green stick, simple, comminuted, hoop, pathological, stress, to fatigue fractures. Blunt, sharp, projectile, and miscellaneous conditions all cause fractures.

Blunt force trauma can be defined as "any injury resulting from a blow from wide instruments that have either a flat or round surface" (Byers 2002: 265). Blunt force trauma can be caused by any hard surface with a wide area to cover bone. These include bats, bludgeons, the ground, cars, trucks, trains, etc. Sharp force trauma is caused by an "implement with a point or edge" (Byers 2002: 266). Sharp force trauma usually leaves behind puncture wounds, chopping marks, or cutting marks. These implements could include axes, knives, glass, forks, or scalpels. Projectile traumas include both blunt and sharp force characteristics. The most common type of projectile trauma is caused by a bullet; however, "any object that travels through the air that impacts with enough energy can cause bone trauma" (Byers 2002: 266). Miscellaneous trauma can include static pressure (strangulation), generalized dynamic pressure (explosions), sawing, chemical trauma, heat or extreme cold trauma (Byers 2002). To be able to fully understand the nature of trauma the forensic anthropologist must be able to identify when the injury occurred in relationship to the instant of the individual's death. Did it occur before, during, or after?

Premortem or antemortem trauma is an injury that occurred before the death of the individual. Premortem traumas have a set of characteristics that the forensic anthropologist can look for to help in identification. Premortem trauma is associated with partial or complete healing of the injury. This is indicative of the increased porosity of the bone near the injury because of bone activity and resorption (Byers 2002). The new porous bone will contrast with the smoother cortical surface of the old, undamaged bone. The edges of the injury will begin to smooth over and lose the sharpness of a fresh injury starting as soon as a week after the injury occurred (Byers 2002).

Perimortem trauma is associated with injuries that occurred around or near the time of death of an individual. The most common aspect of perimortem trauma is the green bone response. The green bone response is "seen when the bone is injured while it is still covered with soft tissue and still contains the fluids present in life. The bone will bend and snap back into place more often than bone damaged postmortem" (Byers 2002: 268). Other characteristics of perimortem trauma are of irregular and sharp edges of the injury with out the smoothness and rounding due to healing, hinging of the bones instead of snapping off, fracture lines, jagged ends, and discoloration due to hematomas (Byers 2002).

Postmortem trauma is damage that occurred after the individual has died and the bones of the skeleton have had a chance to dry out. Postmortem trauma is most commonly associated with forensic taphonomy; the conditions that affect bone after it has been deposited. These include environmental factors such as water and sun damage, rodent and scavenger activity, poor preservation, and poor handling by the excavator. Postmortem trauma can be distinguished from premortem and perimortem because the bone will snap apart like a dry stick, long bones will break at nearly right angles leaving flat ends behind, and the color will differ between the newly broken bone and old non-broken bones (Byers 2002). The new freshly broken bone will be lighter in color than the rest of the skeleton because the new fresh bone has yet to be exposed to the elements like the rest of the body.

PATHOLOGY AND TRAUMA OF UMFC 141

UMFC 141 exhibited both premortem and postmortem defects; however, no obvious perimortem defects were observed. Defects were found on both the cranium and postcranium. These defects are described below.

This individual exhibited small, most likely postmortem, defects to the skull as well as premortem pathological conditions. The premortem pathological conditions are most likely associated with cribra orbitalia, porotic hyperostosis, enamel hypoplasia, and dental caries. The defects associated most likely with cribra orbitalia are located on the left and right orbital plates of UMFC 141 in the form of woven bone. The defects most probably associated with porotic hyperostosis include the area of the frontal squama, left and right orbital margins, left and right maxillas, the left and right zygomatic processes and arches, all along the occipital bone in the presence of pinpricks, as well as the slight depressions along the posterior portion of the sagittal suture and the anterior portion of the lamdoidal suture. Enamel hypoplasia was observed on right canine of the maxilla, and the left and right central incisors of the mandible in the form of transverse lines along the facial surface of UMFC 141. These defects could only have developed while the enamel of the tooth was still developing. These lines can pinpoint the exact age that the individual suffered from some nutritional deficiency or a childhood illness (Roberts and Manchester 1997). A medium sized carious lesion was observed on the occlusal surface of the left second molar of the maxilla, a large cavity was observed on the right second molar situated between the first and second right molar of the maxilla, and a large carious lesion is present on the right third molar situated between the second and third molars of the maxilla. Small cavities were observed on the buccal surface of the left first molar and on the lingual surface of the right second molar of the mandible. The left second premolar of the mandible was observed to be displaced possibly due to crowded dentition, the premolar was situated between the first premolar and first molar pointing in a lingual direction.

There was some postmortem damage to the skull. A circular defect measuring 11.35mm was observed along the left external upper portion of the sphenoid; a circular defect measuring 5.22mm was observed along the left anterior portion of the temporal near where the temporal articulates with the sphenoid; a circular defect measuring 5.41mm was observed along the right anterior portion of the temporal near where the temporal articulates with the sphenoid; the exterior portion of the left and right petrous portion of the temporals show evidence of porotic hyperostosis; and damage to the right lacrimal near the lacrimal groove. This damage is believed to be postmortem due to the porosity and thinness of the surrounding bone. The edges are clean and show no sign of radial cracks associated with perimortem trauma.

The postcranium of UMFC 141 also exhibited premortem and postmortem trauma. This individual displayed what appeared as osteophytosis or lipping on the following elements: the left and right humeral head, the glenoid cavities of the left and right scapulas, the left and right acetabulum, the bodies of thoracic vertebrae 9 through 12 and lumbar vertebrae 1 through 5, the medial and lateral condyles of the distal epiphysis of the left and right femurs, and on the medial and lateral condyles of the proximal epiphysis of the left and right tibiae. Extreme cases of osteophytosis could be seen on the manubrium of the sternum along the clavicular notches as well as with the ankylosis or fusion of thoracic vertebrae 12 to lumbar vertebrae 1. Eburnation or polishing was present along the medial and lateral condyles of the distal epiphysis of the left and right femora as well as on the medial and lateral condyles of the proximal epiphysis of the left and right tibiae.

Ribs 8, 9, and 10 from the right side of UMFC 141 displayed premortem fracturing along the midshaft of each rib. All three ribs were measured from the head to the middle of the healed fracture to help provide orientation of the fracture: rib 8 measured 6.5 cm, rib 9 measured 7.5 cm, and rib 10 measured 8 cm. All three breaks displayed healing which is associated with premortem trauma. The left and right tibiae and fibulae displayed healed fractures in a spiral pattern along the midshaft which appeared as if they were never properly set. The left and right tibiae and fibulae were measured from the proximal epiphysis to the center of the healed fracture on the anterior surface to provide orientation. The left tibia measured 21cm and the right measured 20.5

cm while the left fibula measured 18.5 cm and the right measured 19 cm. The left and right femora displayed an anterior-posterior curvature to the shaft.

The postmortem damage associated with UMFC 141 can most probably be attributed to porosity. All of the twelve ribs from the left and right side displayed porosity on the ends of each bone. The right tibia exhibited porosity along the posterior aspect of the medial malleolus directly posterior to the malleolar groove. The right fibula displayed porosity along the entire proximal epiphysis.

CONCLUSIONS

The defects mentioned above were either premortem or postmortem. Overall, the trauma and pathology seemed to be oriented more towards the lower limbs and vertebral column. This individual, I believe, suffered from numerous pathological conditions. The defects associated with the skull are most likely those of cribra orbitalia, porotic hyperostosis, and enamel hypoplasia. Cribra orbitalia and porotic hyperostosis are associated with iron-deficiency anemia. Porotic hyperostosis is the thinning and often destruction of the outer cranial vault by the sieve-like lesions that appears on the cranial vault, normally the parietals and occipital. Cribra orbitalia is similar in manifestation to that of porotic hyperostosis with the exception that the coral-like lesions appear on the superior orbital plates (Ortner and Putschar 1981). These lesions are lytic in nature. The suggestion that the defects from UMFC 141 may be associated with cribra orbitalia and porotic hyperostosis was based solely on descriptive examples. The placement of the lesions on the cranial vault, orbital plates, and facial bones made the assumption of cribra orbitalia and porotic hyperostosis seem the most likely out of any other possible pathological conditions.

According to Brothwell, hypoplasia means underdevelopment and when associated with the dentition, such as enamel hypoplasia, it literally means defective formation in the form of transverse lines on the enamel of the tooth (Brothwell 1972). UMFC 141 displayed evidence of enamel hypoplasia. Enamel hypoplasia has often been used as stress indicators in the very young because the defects can only form while the teeth are developing and will thus leave a permanent record that will last into adulthood. These stress indicators are most commonly associated with nutritional deficiency and childhood illness (Roberts and Manchester 1997).

Osteoarthritis, in my opinion, is the most likely pathological condition that can be associated with the postcranium. I believe that osteoarthritis is the best choice of joint diseased because of descriptive examples. Osteoarthritis can be caused by a variety of factors including injury, infection, stress, strain, and age. It is commonly believed that "increasing age, a genetic predisposition, obesity, activity/ lifestyle and environmental factors such as climate may all contribute to [osteoarthritis'] development" (Roberts and Manchester 1997: 105). Osteoarthritis is the most common joint disease. It is non-inflammatory and it affects the synovial joints. Osteoarthritis cannot be determined just because of the presence of osteophytes; eburnation is actually the sure sign of osteoarthritis (Roberts and Manchester). There are quite a few other types of joint diseases that UMFC 141 could have been afflicted with; however, the presence of eburnation on the femurs and tibiae and the nature of where the disease was affecting is most likely associated with osteoarthritis and not any of the others. Septic arthritis, rheumatoid arthritis, psoriatic arthritis, and ankylosing arthritis are all inflammatory arthritis' that mainly affect the hands and feet and the lower spine. The hands and feet of UMFC 141 showed no obvious signs of joint disease and the presence of lipping and fusion in the spinal column is most probably tied to that of the lower limbs and the stress placed on them from the healed fractures of the left and right tibiae and fibulae.

The anterior posterior curvature of the left and right femora were most likely associated with the stress placed on them from the healed fractures of the left and right tibiae and fibulae. "If a person practices a very heavy manual occupation which severely stresses the joints; it is likely that a particular patterning may occur for that specific occupation" (Roberts and Manchester 1997: 107) and the same can almost certainly be said for an individual who has to maneuver around on lower limbs that were broken and then never healed properly. The presence of the healed fractures indicate that the individual must have survived the injury as does the curvature of the femora and the severe case of osteoarthritis in the knees and lower back.

Based on the evidence indicated above, I believe that UMFC 141 suffered from cribra orbitalia, porotic hyperostosis, enamel hypoplasia, and osteoarthritis. I must emphasize that I do not possess a medical degree nor do I possess any form of medical training and this conclusion was based on associations and similarities between the pathologies from UMFC 141 and pictures and descriptions of various pathologies in an assortment of pathology books. For more conclusive analysis a medical professional would be the best candidate to reevaluate the remains. No perimortem trauma was observed and therefore no obvious cause of death can be determined.

TIME SINCE DEATH

Time since death was estimated as at least one year because it takes at least one year for a body to completely skeletonize in Montana. Nevertheless, as stated earlier the remains of this individual were reportedly acquired from China. Early modern or late historic is suggested because the broken lower legs were never properly set as bones are more likely to be in more modern times; however, it is quite possible that the individual did not have adequate access to modern medicine and was forced to adapt.

CONCLUSIONS

UMFC 141 was probably that of a male of predominantly Asian ancestry with a slight mix of European ancestry, possibly between the ages of 35-44, with a height around 5 feet 2 inches and 5 feet 4 inches, with a weight around 130.2±25.2 – 136.2±26.2 pounds. The individual suffered from premortem fractures to the left and right tibiae and fibulae along the midshaft. Ribs 8, 9, and 10 on the right side were also fractured premortem. The individual suffered from osteoarthritis in the lower back, and in both arm and leg joints. UMFC 141 also suffered from poor dental health as can be seen in presence of various carious lesions. The presence of porotic hyperostosis, cribra orbitalia, and enamel hypoplasia suggests that this individual suffered from an iron deficiency anemia and/or was undernourished. Time since death of this individual is estimated to at least one year to early modern or late historic.

Appendix I

CRANIAL MEASUREMENTS
(all measurements are in mm)

MAMIMUM LENGTH (g-op): 179

MAXIMUM BREADTH (eu-eu): 125

BIZYGOMATIC BREADTH (zy-zy): 131

BASION-BREGMA (ba-b): 135

CRANIAL BASE LENGTH (ba-n): 102

BASION-PROSTHION LENGTH (ba-ids): 96

MAXIMUM ALVEOLAR BREADTH (ecm-ecm): 63

MAXIMUM ALVEOLAR LENGTH (pr-alv): 55

BIAURICULAR BREADTH (ALB): 121

UPPER FACIAL HEIGHT (n-pr): 71

MINIMUM FRONTAL BREADTH (ft-ft): 87

UPPER FACIAL BREADTH (fmt-fmt): 98

NASAL HEIGHT (n-ns): 54

NASAL BREADTH (al-al): 25

ORBITAL BREADTH (d-ec): left 40, right 40

ORBITAL HEIGHT (OBH): left 38, right 38

BIORBITAL BREADTH (ec-ec): 96

INTERORBITAL BREADTH (d-d): 21

FRONTAL CHORD (n-b): 111

PARIETAL CHORD (b-l): 112

OCCIPITAL CHORD (l-o): 96

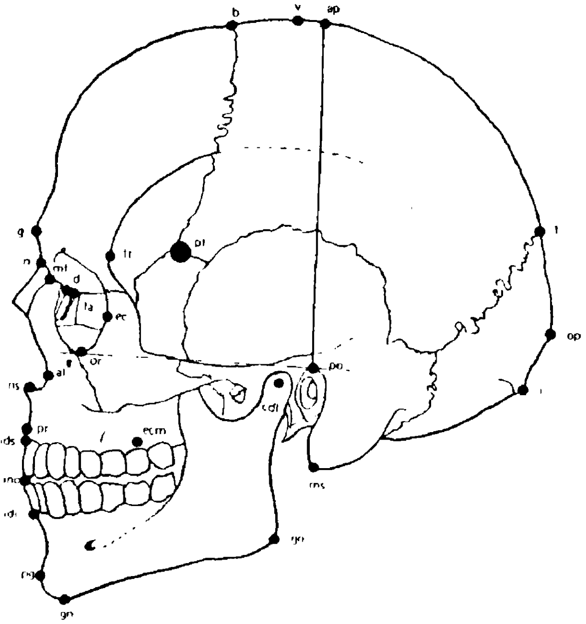
FORAMEN MAGNUM LENGTH (ba-o): 38

FORAMEN MAGNUM BREADTH (FOB): 32

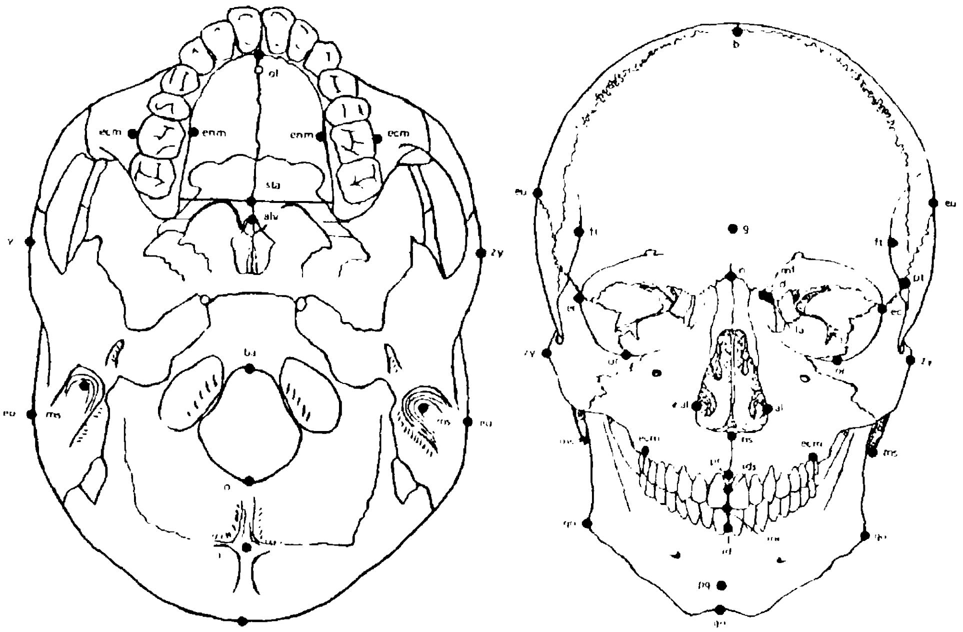
MASTOID LENGTH (po-ms): left 29, right 29

Appendix II

ANTHROPOMORPHIC LANDMARKS OF THE SKULL



ANTHROPOMETRIC LANDMARKS OF THE SKULL



(From Bass 1995:69-71)

Appendix III

POSTCRANIAL MEASUREMENTS

(all measurements are in mm)

	Left		*Right*
Clavicle:			
MAXIMUM LENGTH	129.77		135.49
CIRCUMFERENCE AT MIDDLE	38		37
Scapula:			
MAXIMUM LENGTH	150.88		147.57
MAXIMUM BREADTH	97.52		97.74
SPINE LENGTH	123.48		118.95
SUPRASPINOUS LINE LENGTH	50.80		52.37
INFRASPINOUS LINE LENGTH	112.11		112.79
GLENOID CAVITY LENGTH	37.64		39.32
Sternum:			
MANUMBRIUM LENGTH		43.68	
MESOSTERUM LENGTH		101.09	
STERNEBRA WIDTH		24.20	
Humerus:			
MAXIMUM LENGTH	285		290
MAXIMUM DIAMETER AT MIDSHAFT	20.93		18.90
MINIMUM DIAMETER AT MIDSHAT	36.47		36.73
MAXIMUM VERTICAL DIAMETER OF HEAD	45.35		46.21
TRANSVERSE DIAMETER OF HEAD	44.21		44.53
LEAST CIRCUMFERENCE OF SHAFT	63		64
EPICONDYL WIDTH	60.06		60.48
Ulna:			
MAXIMUM LENGTH	244		246
Radius:			
MAXIMUM LENGTH	221		220
Coxal:			
MAXIMUM LENGTH	201		197
ILIAC BREADTH	151		150
ISCHIUM LENGTH	80.03		80.50
PUBIS LENGTH	68.99		68.94
Sacrum:			
NUMBER OF SEGMENTS		5	
ANTERIOR HEIGHT		113.98	
ANTERIOR BREADTH		107.12	
Femur:			
MAXIMUM LENGTH	399		395
VERTICAL DIAMETER OF THE HEAD	45.32		43.41
POPLITEAL LENGTH	127.75		125.30
BIOCONDYLR WIDTH	72.29		71.79
TROCHANTERIC OBLIQUE LENGTH	385		383
Tibia:			
MAXIMUM LENGTH	336		335
CIRCUMFERENCE AT NUTIRIENT FORAMEN	92		95
Fibula:			
MAXIMUM LENGTH	323		316

REFERENCES

Bass, W.M., 1995. Human Osteology: A Laboratory Field Manual. Fourth Edition. Columbia: Missouri Archaeological Society.

Brothwell, D.R., 1972. Digging up Bones. Second Edition. London: British Museum of Natural History.

Burns, K.R., 1999. Forensic Anthropology Training Manual. Upper Saddle River: Prentice Hall.

Byers, S., K. Akoshima, and B. Curran, 1989. Determination of adult stature from metatarsal length. American Journal of Physical Anthropology 79: 275-279.

Byers, S.N., 2002. Introduction to Forensic Anthropology: A Textbook. Boston: Allyn and Bacon.

Dupertuis, C.W., and J.A. Hadden, 1951. On the reconstruction of stature from long bones. American Journal of Physical Anthropology 9: 15-53.

Dwight, T., 1905. The Size of the Articular Surfaces of the Long Bones as Characteristics of Sex: An Anthropological Study. American Journal of Anatomy 4: 19-32.

Genovés, S., 1967. Proportionality of the Long Bones and Their Relation to Stature among Mesoamericans. American Journal of Physical Anthropology 26: 67-78.

Giles, E. and O. Elliot, 1962. Race Identification from Cranial Measurements. Journal of Forensic Sciences 7: 147-157.

Giles, E. and O. Elliot, 1963. Sex Determination by Discriminant Function Analysis of Crania. American Journal of Physical Anthropology 21: 53-68.

Giles, E., 1993. Modifying Stature Estimation from the Femur and Tibia. Journal of Forensic Sciences 38 (4):758-760.

Howell, W.W., 1973. Cranial Variation in Man: A Study by Multivariate Analysis of Patterns of Difference among Recent Human Populations. Volume 67. Cambridge: Peabody Museum of Archaeological and Ethnology.

Howell, W.W., 1995. Who's Who in Skull: Ethnic Identification of Crania from Measurements. Volume 82. Cambridge: Peabody Museum of Archaeology and Ethnology.

Hrdlička, A., 1942. The Adult Scapula: Additional Observation and Measurements. American Journal of Physical Anthropology 29: 363-415.

Iscan, M.Y. and P. Miller-Shaivitz, 1984. Discriminant function sexing of the tibia. American Journal of Forensic Sciences 29: 1097-1093.

Jantz, R.L., 1992. Modification of the Trotter and Gleser female stature estimation formulae. Journal of Forensic Science 37(5): 1230-1235.

Jantz, R.L., 1993. Author's Response. Journal of Forensic Science 38(4): 760-763.

Jantz, R.L., D.R. Hunt, and L. Meadows, 1995. The measure and mis-measure of the tibia: implications for stature estimation. Journal of Forensic Science 40(5): 758-761.

Jit, I., V. Jhingan and M. Kulkami, 1980. Sexing the Human Sternum. American Journal of Physical Anthropology 53: 217-224.

Krogman, W.M., 1962. The Human Skeleton in Forensic Medicine. Springfield: Charles C. Thomas.

Lovejoy, C., R.S. Meindl, R.P. Mensworth and T.J. Barton, 1985. Multifactorial Determination of Skeletal Age at Death: A Method and Blind Tests of its Accuracy. American Journal of Physical Anthropology 68: 1-14.

Meadows, L., and R.L. Jantz, 1992. Estimation of stature from metacarpal lengths. Journal of Forensic Science 37(1): 147-154.

Montague, A., 1960. An Introduction to Physical Anthropology. Springfield, IL: Charles C. Thomas.

Moore-Jansen, P.H., S.D. Ousley and R.L. Jantz, 1994. Data Collection Procedures for Forensic Skeletal Material. Third Edition. Knoxville: University of Tennessee Press.

Musgrave, J.H., and N.K. Harneja, 1978. The estimation of adult stature from metacarpal bone length. American Journal of Physical Anthropology 48: 113-120.

Ortner, D. J., and W.G. J. Putschar, 1981. Identification of pathological conditions in human skeletal remains. Smithsonian Contributions to Anthropology 28: 1-457.

Ousley, S.D. and R.L. Jantz, 1996. FORDISC 2.0: Personal Computer Forensic Discriminant Functions. The University of Tennessee, Knoxville.

Pickering, R.B. and D.C. Bachman, 1997. The Use of Forensic Anthropology. Boca Raton: CRC Press.

Roberts, C. and K. Manchester, 1997. The Archaeology of Disease. Second Edition. Ithaca: Cornell University Press.

Rogers, T., and S. Saunders, 1994. Accuracy of sex determination using morphological traits of the human pelvis. Journal of Forensic Science 39: 1047-1056.

Skelton, R., 2003. ANTH 564 Advanced Forensic Anthropology Manual. Montana: University of Montana Press.

Stewart, T.D., 1979. Essentials of Forensic Anthropology: Especially as Developed in the United States. Springfield, IL: Charles C. Thomas.

Stewart, J.H. and W.F. McCormick, 1983. The Gender Predictive Value of Sternal Length. The American Journal of Forensic Medicine and Pathology 4: 217-220.

Thieme, F.P., 1957. Sex in Negro Skeletons. Journal of Forensic Medicine 4:72-81.

Trotter, M. and G.C. Gleser, 1952. Estimation of Stature from Long Bones of American Whites and Negroes. American Journal of Physical Anthropology 10: 463-514.

Trotter, M. and G.C. Gleser, 1958. A re-evaluation of estimation of stature based on measurements of stature taken during life and of long bones after death. American Journal of Physical Anthropology 16: 79-123.

Trotter, M., 1970. Estimation of stature from intact long limb bones. In Personal Identification in Mass Disasters, edited by T.D. Stewart. Washington, D.C.: National Museum of Natural History, Smithsonian Institution. Pp. 71-84.

Walker, P.L. and D.C. Cook, 1998. Brief communication: Gender and sex: vive la difference. American Journal of Physical Anthropology 106: 255-259.

Walsh-Haney, H., C. Katzmarzyk and A.B. Falsetti, 1999. Identification of Human Skeletal Remains: Was he a she or she a he? In Forensic Osteological Analysis: A Book of Case Studies, edited by S.I. Fairgrieve. Springfield, IL: Charles C. Thomas. Pp. 17-35.

Washburn, S.L., 1948. Sex Differences in the Pubic Bone. American Journal of Physical Anthropology 6:199-208.

White, T.D. and P.A. Folkens, 1991. Human Osteology. San Diego:Academic Press.

Wilder, H.H., 1920. A Laboratory Manual of Anthropometry. Philadelphia: P. Blakiston's Son & Co.