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A comprehensive examination of University of Montana Forensic Case #12

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Abstract

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Chairperson: Dr. Randall Skelton RS

The examination of skeletal remains using the techniques perfected by forensic anthropologists can be a very important part of the law enforcement process. This project looked to apply as many of these techniques as possible to University of Montana Forensic Case # 12. This case consists of a set of human skeletal remains housed in the Physical Anthropology Laboratory at the University of Montana-Missoula.

The methods applied to the examination of this case included sex determination from the skull, discriminant function analysis, clavicle, scapula, humerus, coxal bones, femur, tibia, and sacrum. Race or ancestry was estimated using non-metric characteristics from the skull, discriminant function methods, and visual assessment of the sacrum, scapula, femur, and teeth. Age estimation was determined using dental attrition, cranial suture closure, clavicle epiphysis, sternal rib end, long bone epiphysis, and osteophytosis development. Finally, the rest of this paper consists of sections looking at stature and weight estimation, the pathology and trauma exhibited, and a literature review of age estimation using the sternal rib end.

Acknowledgements

First and foremost, I would like to thank my wife Amy, for her support during this project. I would also like to thank Dr. Randy Skelton for his guidance from the planning stages through the completion of this paper. Finally, I would like to thank my family for their support and encouragement.

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Background Information

On September 1st, 1983, Dr. Charline G. Smith of the department of Anthropology at the University of Montana-Missoula, was called to the Lewis and Clark county coroners' office of Mr. Mickey Nelson to examine a set of partial human remains (Skeletal Analysis Report, Dr. Charline Smith: September 6, 1983). The initial discovery of the remains occurred during the excavation of a cliff for the expansion of Cruse Avenue near the old school house administration building on Allen Street in Helena, Montana. (Independent Record, August 31, 1983: Vol. 40, No. 283)

According to published reports, initial theories of the case revolved around the idea that the individual may have been part of a population of Chinese laborers who lived in Helena starting around the 1860's when gold was discovered in the area. The Independent Record ran a story in their August 31, 1983 edition, noting that a Chinese cemetery "dating back to the gold rush days, lies in the area", but that its "exact location had never been clearly defined or marked". Furthermore, according to the news story, it is likely that the graves from that cemetery would most likely have been moved when "the original central school was built in 1876" (Independent Record, August 31, 1983: vol. 40, No. 283).

A thorough analysis of the remains was carried out by Dr. Smith in early September 1983 at the Physical Anthropology laboratory at the University of Montana-Missoula. In her report, she concluded that the individual was most likely a Caucasoid male, around the age of 50 years at the time of death. She also concluded that the individual was probably about 5ft. 6inch. tall. As far as pathology and trauma is concerned, she stated that "an interesting pathology, which has little expected forensic value, is a thickening of the right medial humerus from just below the head to about 7cm down the shaft" (Smith 1983). She goes on to say that the pathology "does not precisely resemble either a bony callous due to fracture, or an ossified tendon attachment" (Smith 1983). Although she was unable to determine an exact time since death estimation on the individual, she did speculate that the individual was buried sometime around the turn of the century based on the condition of the bones, and small pieces of wood that were most likely from a "plain" coffin.

Literature Review: Aging from the Sternal Rib End

The use of the sternal rib end in age at death estimations is a very important one for forensic anthropologists. There are two distinct methods that have been developed over the years, histological methods, and morphological methods that look at the "mineralization of the costal cartilage as an indicator of age" (Bass 1995: 139).

In 1980, W.F. McCormick, M.D. published a paper regarding age at death estimations using the sternal rib ends in The Journal of Forensic Sciences. In the paper, he notes that aging human remains from the sternal rib ends is a "readily available technique for the approximation of age at death of partially or completely skeletonized material, is inexpensive and requires little expertise" (McCormick 1980: 737). His research into the subject consisted of the removal of the chest plate of autopsied individuals, and then exposing those chest plates "in a enclosed outdoor environment for up to four months" (McCormick 1980: 737). A total of 20 chest plates were used and some were "placed in the sun, others in dense shade, and still others partially or completely buried beneath gravel sand and grass" (McCormick 1980: 737). A examination of the chest plates took place at two-to-three week intervals. He concluded from this research that although this method of aging may be "less precise than some other methods currently available, it's ease of use, low cost, ease of storage of the single X-ray film, and lack of need for considerable personal experience and expertise in evaluating skeletal materials recommend it's use as a "second best method" (McCormick 1980: 740-741).

In 1984, Iscan et al. published a very influential article in The Journal of Forensic Sciences titled "Age Estimation from the Rib by Phase Analysis: White Males", which was then followed up a year later with "Age Estimation from the Rib by Phase Analysis: White Females". In these articles the authors chose to study the rib for age determination because "radiographic and histologic research and direct morphologic observation of the sternal extremity indicated that this area showed changes throughout life" (Iscan et al. 1984a: 1095). Males and females were researched separately because "radiographic studies have presented evidence of sexual dimorphism in both the manifestation and rate of change in the rib" (Iscan et al. 1985: 853).

The authors started their research by first collecting the fourth rib from 118 males autopsied at the Broward County Medical Examiners Office (Iscan et al. 1984a: 1095) and the fourth rib of 86 females (Iscan et al. 1985: 854). All of the samples taken were form specimens of known sex, age and race (Iscan et al. 1984a: 854, 1985: 1095). Once these bones were removed they were analyzed and partitioned into age phases based on morphological changes. In males, the first noticeable changes "were not seen until after the age of sixteen" (Iscan et al. 1984a: 1095), while in females the first signs of change start "appearing at the age of around fourteen years" (Iscan et al. 1985: 854). In all, the authors were able to break both male and female aging of the sternal rib ends into eight total age phases based on the examination of morphological changes in the sternal end of the 4^{th} rib. These phases are defined in both males and females, by changes "noted in the form, shape, texture, and overall quality of the sternal rib end" (Iscan et al. 1984: 1096). These changes can be seen as occurring on three different components of the rib end, the pit shape, pit depth, and rim and wall configurations. (Iscan et al 1984b: 148-152).

The authors of this study note that it is important to keep in mind that "several factors should be considered when one uses a method of age estimation from the skeleton. These include interobserver error, human variability, occupation, general health, and the effects from disease" (Iscan et al 1984a: 1103). As a side note, this was the method of age determination from the ribs that I used in the examination of UMFC 12 (please see "age from sternal rib end" section of this paper). At this point in time it is the easiest, clearest, and most thorough method of age at death estimation from the ribs available. It also was the method that was best suited for the analysis of UMFC 12 based on the equipment available in our Physical Anthropology Laboratory.

In 1993, Stout et al. wrote a paper that looked at age determination from the sternal rib end based on histology. This technique involved "taking bone samples from the area adjacent to the sternal end used in the morphological aging technique developed by Iscan" (Stout et al. 1994: 779). This method involved the removal of a 3-5mm thick transverse cross-section" that were then sliced into sections and prepared for "histological analysis following routine petrographic procedures" (Stout et al. 1994: 779). From these sliced sections, the researchers determined the intact osteon density, the fragmentary osteon density, and the osteon population density (Stout et al. 1994: 779). They concluded that "an analysis of variance for repeated measures found no significant differences for the means for known ages at death, histologically estimated ages, and those based upon rib phase analysis among 6 test sets" (Stout et al. 1994: 780). What this means is that this method was about as accurate as Iscan's age phase models, but is much more technical in application.

Other researchers also found this to be the case as well. In a paper titled "Evaluation of Morphological and Histological Adult Skeletal Age-at-Death Estimation Using Ribs", Dudar et al. applied both Iscan's morphological approach and Stout's histological approach to a set of human remains. Using a sample of 55 individuals "from university anatomy teaching facilities of southern Ontario, and documented archaeological cemeteries: the Harvie site (southwestern Ontario) and the historic St. Thomas Anglican Church site in Belleville, Ontario" (Dudar et al. 1993: 678), the researchers found that "on their own, the sternal rib end and rib histological age-at-death estimation techniques fulfill their objectives. Careful and consistent applications of the investigated methodologies should provide reliable and accurate estimates" (Dudar et al. 1993: 684). However, they do note that "combining the age related modeling and remodeling mechanisms used by the techniques has the distinct advantage of controlling for more of the variability due to biomedical influences" (Dudar et al. 1993: 684). In other words, using both methods is better than using either one on its own.

Russell et al. independently researched morphological change in the fourth rib as an indicator of age and found that "changes in morphology of the sternal surface at the 4^{th} rib can be used to predict age at death" (Russell et al. 1993: 61). They go on to say that "the average inaccuracy and bias in the 4^{th} rib aging technique make it a acceptable method for inclusion in a multifactorial aging scheme" (Russell et al. 1993: 61). Russell's research did not address Iscan's research for females, but they did note "a non-significant tendency for blacks to be under aged (using Iscan's morphological changes) more than whites" (Russell et al. 1993: 61).

Finally, Catey (2000) researched "the accuracy and reliability of determining skeletal age at death using the sternal end of the fourth right rib" (Catey 2000: 2). Using the standards developed by Iscan et al. (1985a), Catey determined that "there is, in fact, change that occurs in the medial wall of the rib, taking place in shape, structure, and overall quality of the bony material" (Catey 2000: 45). This change, he concludes, correlates "with real age, and are patterned and consistent on average" (Catey 2000: 45). Therefore, "predictive power is strong for the estimation of age at death based upon phase analysis of the morphological changes indigenous to the medial rib (Catey 2000: 46).

Overall, the research noted in this section shows that sternal rib aging methods are indeed an accurate method of determining age at death from human remains. However, as both Dudar and Russell note, these methods should always be used in conjunction with other methods of age determination within a multifactorial framework. As with most, if not all methods of age at death estimation techniques, I certainly would not base my age at death determination solely off sternal rib analysis alone. Nonetheless, this method is fairly accurate (for example Russell found that it was approximately 3.43 % inaccurate for white males 20-29 years old, but up to16% inaccurate for white males 50-59 years old. Russell et al. 1993: 56)) and is an excellent method to include in any age at death estimation from skeletal material.

My Involvement

I decided to do a comprehensive examination of these remains for a number of reasons. First and foremost, I think that it is vitally important that we know as much information as possible about the individuals housed in our Physical Anthropology Laboratory. Not necessarily who the individual was in life (as far as name, and family etc.), but information that is critical to students training to become forensic anthropologists by studying the remains in our lab. If you look through the case files of the individuals housed in the Physical Anthropology Laboratory, you will notice that there are reports on each case done by students citing varying age, sex and race estimations. This is because there are a number of methods that can be used to make these determination, some more reliable than others. Also, some students may have been more thorough than others. In doing a comprehensive examination of UMFC 12 I hope to give students, and the curator of our laboratory, some in depth information regarding this individual. I will use as many methods as possible to determine the inventory, race, age, and sex of the individual, as well as my opinion regarding the pathology seen on the remains. I do this in the hopes that I will be able to shed some light on at least one of the cases housed in the Physical Anthropology Laboratory. One thing to note, I do not see this report as being the final say on these remains. Every year more and more methods are developed to help investigators identify skeletal remains. Also, as you will see, a lot of the methods that are applied in forensic anthropology cases are subjective and open to individual interpretation. What I see on the bones may not necessarily be what another examiner does. Nonetheless, hopefully the information that I was able to gather from the examination of UMFC 12 will allow it to become a better teaching tool for future students of Forensic Anthropology at the University of Montana-Missoula. With that, let us now take a look at the inventory of remains that make up the University of Montana Forensic Case # 12 (UMFC 12).

Inventory

The first thing that I am going to discuss is the inventory. It is widely known that there are two hundred and six bones in the average human skeleton (there can be more or less due to amputation, sesmoid bones, wormian bones etc.). When participating in a comprehensive forensic examination, it is always best to recover as many bones as possible. Determining what skeletal elements are present should be the first step in a forensic analysis. It will determine what methods of identification can be applied, which in return can greatly affect the accuracy of your conclusions. This individual was fairly complete, with a majority of the cranial and post-cranial skeleton available for analysis. My classification of the bones as complete or partial (incomplete), was done simply by considering whether or not a major feature of the bone was missing.

Cranial Bones

The cranial bones, or skull "comprises the braincase or cranium and the lower jaw or mandible; often, the hyoid bone is included" (Schwartz 1995: 23). Furthermore, the skull can be subdivided into the calvaria (calvarium), and the face (facial skeleton). Traditionally, the calvaria "is composed of eight major bones: the ethmoid, frontal, occipital, parietal [right and left], sphenoid, and temporal [right and left]" (Schwartz 1995: 24).

The following bones of the calveria were part of UMFC 12. The ethmoid bone was present and nearly complete. However, the majority of the crista galla, a major feature of the bone is broken off. The frontal bone of the individual was present and complete. The occipital bone was present, but was only a partial specimen. A small portion of the bone just inferior to the right mastoid process measuring 31.2by 37.5 millimeters (mm) was missing. Both the left and right parietal bones were present and complete, as was the sphenoid bone. Finally, both the temporal bones were available for analysis, however, only the left bone was complete. The right bone was only a partial specimen in that a small triangular shaped portion, measuring 18.7mm (including a small portion of the mastoid process) was missing.

As with the calvaria, the facial skeleton was also very complete. The following bones of the facial skeleton were complete and available for analysis; the right and left nasal bones, the right and left lacrimals, the right and left zygomas, the right and left maxilla, the right and left palantine, the right and left inferior nasal concha., and the mandible. Two of these bones, the right maxilla and the mandible which I considered complete, did display some abnormalities that I will discuss further in the Pathology and trauma section of the paper.

As with skeletal material, an examination of dentition can also be extremely important to forensic anthropologists. In some cases, teeth may be the only reliable resource a forensic scientist has to use when dealing with human remains because "teeth are constructed of dense, hard material, resist decay in the ground, and often outlast bones" (Bass 1995: 273). There are four distinct types of teeth that make up the average humans dentition. These are incisors, canines, premolars and molars. Of these four types they can further be sub-classified into upper and lower, and left and right. Finally, they can be sub-classified once again as incisor 1 or 2, premolar 1 or 2, and molar 1, 2, or 3. In total, the average adult human will have (if none were lost or removed) 32 teeth in his or her mouth. These include eight incisors, four canines, eight premolars and twelve molars.

In some individuals, more or less teeth may develop. For example, "supernumerary teeth are extra teeth that may occur in the incisor, canine, premolar, or molar tooth groups" (Bass 1995: 290). Also, "occasionally, one or more teeth normally present may be absent congenitally" (Bass 1995: 290). This of course is for adult dentition only, humans will develop two sets of teeth in their lifetime, the first being deciduous teeth that begin to erupt at about "six months of age" (Bass 1995: 274) and consist of only twenty teeth. For UMFC # 12, the following adult dentition was present on the lower jaw (mandible) and available for examination; the left 1st and 2nd incisors, the left canine, the left 1st and 2nd premolars, the left 1st molar and the left 3rd molar, the right 1st and 2nd incisors, the right canine, the right 1st and 2nd premolar, and the 1st right molar.

On the upper jaw, the following teeth were present: the left canine, the left 2nd premolar, the left 2nd molar, the right 1st molar and the right 3rd molar. All other dentition on the individual was absent and was lost either premortem or postmortem (see pathology and trauma).

Post-Cranial Bones

Now that we described the cranial skeletal elements of UMFC 12, let us now take a look at the post-cranial bones. Once again, the more bones available for analysis the better, because " every piece of bone tells a story about the individuality of its possessor, a story which, if properly unfolded, may result in a positive identification" (Krogman and Iscan 1986: 21) This is true right down to the smallest bones of the hands and feet, and the smallest fragments of larger bones. Every bone in the human body can potentially be of great importance to investigators attempting to make a positive identification.

Now let us take a look at the postcranial bones that are a part of UMFC 12. As with the cranial bones, I will label each bone as partial (or incomplete) or complete, and give a brief description if I considered the bone partial.

To begin, both the right and left clavicles were complete. The right humerus was a partial specimen. There was a section of bone missing on the proximal end, starting on the head and extending down through the neck and into the shaft of the bone. This section measures 52.5 mm by 34.1 mm at its widest points respectively. The left humerus was also incomplete. There is a section of the proximal end of the bone missing, which encompasses approximately ½ of the head of the bone and extends down into the neck. The missing section measures 41.6 mm by 46.9 mm. The right and left radius were both complete, although each displayed a small amount of wear and tear on the head. The right ulna is a partial specimen. The majority of the olecranon is missing, as well as the semilunar notch. The left ulna is complete.

The right scapula was incomplete. The majority of the spine is missing as well as the medial (vertebral) border, subscapular fossa, infraspinous fossa, and the inferior angle. The left scapula was also partial. Again, the spine, medial border, subscapular fossa, and the infespinous fossa are all missing. A small portion of the inferior angle was present for the left scapula, however, it is separated completely from the rest of the bone.

The following bones of the right hand were also identified; the capitate (complete), the 1st metacarpal (complete), 2nd metacarpal (complete), 3rd metacarpal (complete), and the 4th metacarpal (complete). The metacarpals were distinguished as such by the size and shape of the distal and proximal ends and the shape of the articular surface as prescribed by Bass (Bass 1995: 185-187). Bones of the left hand that were identified included the hamate (complete), trapezoid (complete), trapezium (complete), 1st metacarpal (complete), 2nd metacarpal (complete), 3rd metacarpal (complete), and 4th metacarpal (complete). For the right and left hand combined there were 9 phalanges identified. These included 6 proximal phalanges, 1 middle phalange, and 2 distal phalanges.

Moving away from the upper appendages of the body, let us now take a look at the sternum, ribs and vertebrae. The sternum was incomplete in that the manubrium was broken off from the body and unavailable for analysis.

There were a number of ribs available for analysis. One thing to keep in mind is that "it is difficult to tell the exact number of the rib without a comparative skeleton" (Bass 1995: 137). There are plenty of comparative skeletons in our lab that were very useful in this task, however many of the ribs were fragmented which makes the job much harder than it already is. Nonetheless, the following ribs were identified and were considered complete. The left 1st, right 1st, left 3rd, left 4th and the right 4th. The right 2nd was also identified but it was incomplete in that it was lacking the ventral end. Six other rib fragments were able to be identified as coming from the right side using the steps described by Robert W. Mann (Mann 1993). However, I was unable to determine the sequence of these fragments.

The vertebral column of the individual; was fairly complete. The average "normal" human being has a total of 24 vertebrae, 1 sacrum and a coccyx bone making up his or her spinal column. The vertebrae can then be broken down into 7 cervical vertebrae (cervical vertebrae 1-7 or C1-C7), including two specialized vertebrae called the atlas (C1), and the axis (C2), 12 thoracic vertebrae (thoracic vertebrae 1-12 or T1-

T12), and 5 lumbar vertebrae (lumbar vertebrae 1-5 or L1-L5). Using Bass (1995), and an articulated comparison skeleton, I was able to identify and analyze the following vertebrae that were a part of UMFC 12: cervical vertebrae 1 (C1) which was complete, either cervical vertebrae 3, 4, 5, or 6, which was identified because "the ventral (front) portion of the articular surface of the body of numbers 3-6 ... are lower in the center than on the sides" (Bass 1995: 105). Moving on to the thoracic vertebrae, seven of the first nine thoracic vertebrae were available for analysis. Using Bass's descriptions on page 108 of his book (Bass 1995), I was able to determine that all seven of these vertebrae had half pits on their superior and inferior borders of their bodies. However, all seven specimens were incomplete. All were missing the spineous process, 5 of them were missing the right and left transverse processes, and 2 of them were missing all superior and inferior articular surfaces. Staying with the thoracic vertebrae, 10 and 11 were also identified. Both of these bones had whole pits on the body but lacked a lower costal half pit. It was determined that neither of these bones were thoracic vertebra 12 because they did not articulate with Lumbar 1 (L1). Both T11 and T12, which were distinguished using size only, were partial specimens. T10, lacked the right and left transverse processes, the spineous process, and the right and left, lower and upper articular surfaces. T11 lacked the right and left transverse processes, the spineous process, and the right inferior articular surfaces.

Moving on to the lumbar vertebrae, all five, L1-L5, were able to be identified, but were only partial specimens. Lumbar vertebrae 1 (L1) was missing the spineous process, the right transverse process, and the right inferior articular surface. Lumbar vertebrae 2 (L2) was missing the right transverse process, and both inferior articular surfaces. Lumbar vertebrae 3 (L3) was missing the majority of the right transverse process, and the spineous process. Lumbar vertebrae 4 (L4) was missing the spineous process. Finally, lumbar vertebrae 5 (L5) was missing the left inferior articular surface, and the left transverse process. The sacrum of the individual was incomplete with a majority of the specimen unavailable for examination. The portion of the bone that was available was broken off at the right ala or wing, just inferior to the promontory, and just superior to the first sacral foramen.

Continuing on, let's now look at the coxal bones of UMFC 12. The coxal bones are very useful to forensic anthropologists. The coxals or hip bones, exhibit a number of diagnostic traits that are especially useful in the determination of sex and age, making their careful recovery very important. Unfortunately, the coxal bones of UMFC 12 were in very bad shape.

The left coxal was incomplete. Portions missing from this bone included all sections inferior to the base of the greater sciatic notch, including the lesser sciatic notch, the ischium, and the lower margin of the obturator foramen. Just superior to the greater sciatic notch there was a section of bone absent that includes the posterior inferior iliac spine and a portion of the posterior superior iliac spine. Finally, the pubis portion was present but broken off at the acetabulum and the ventral margin.

The right coxal was also a partial specimen broken into a number of pieces. The first piece included the greater sciatic notch, the posterior portion of the acetabulum, and a portion of the main body of the ischium (not including the ischial tuberosity). The second piece included the illium, the crest of the illium, the iliac fossa, the anterior superior iliac spine, and the anterior inferior iliac spine. The two pieces were broken apart at approximately the anterior superior iliac spine. The pubis is present, but as with the left coxal, it is broken off at the acetabulum and the ventral margin.

To conclude the inventory section of this report, let us now take a look at the lower appendages of the individual, which includes the legs (femurs, tibias, and fibulas) and the feet (tarsals, metatarsals, and phalanges). I classified the right femur as partial. A section of bone measuring 47.7mm by 49.2 mm was missing which included portions of the greater trochanter and lesser trochanter. Also, a large portion of the lateral epicondyle was missing.

The left femur was also a partial specimen. A large portion of both the greater trochanter and lesser trochanter were missing. This section measured 66.4mm by 37mm respectively. On the distal end, a section of the posterior portion of the lateral epicondyle is missing.

Moving down the legs, both the right and left tibias were present. The right tibia was a partial specimen. The majority of the lateral condyle was missing, as well as the fibular articular surface, and a vast majority of the tibial tuberosity. This section of deterioration extends down the popliteal line to its conjunction with the anterior crest. The left tibia was complete.

There were no positively identified sections of fibula available for analysis, but I can say with some confidence based on shape and curvature that there were three probable fibula fragments (1 left, 1 right, and 1 undetermined) included with UMFC 12. However, due to the size and deterioration of these fragments I cannot say this conclusively.

Many bones of the feet were present as well. The following tarsals of the right foot were able to be identified: right calcaneus (complete), right talus (complete), right navicular (complete), right medial cuneiform (complete), right intermediate cuneiform (complete), and the right cuboid (partial, it was missing the majority of the body including the smooth non-facet surface). Moving on to the right metatarsals, the 1st (partial, lateral portion of the bone is sheared away), 3rd (partial, the proximal medial portion is missing), and 4th (partial, the proximal end is missing) metatarsals were available for analysis. Finally, the last bone of the right foot that was identified, was a proximal phalanx (complete). Left foot tarsal bones that were able to be identified included: left medial cuneiform (complete), left lateral cuneiform (complete), and the left cuboid (partial, it was missing the majority of the bone including most of the pointed articular facet and the smooth non-facet surface). Moving on to the left metatarsals, the 1st (partial, distal plantar portion of the bone is missing), 2nd (partial, distal plantar portion is missing), 3rd (partial, distal lateral portion is missing), and 4th (complete) metatarsals were identified. Finally, the following phalanges were identified: 1 proximal phalanx and the distal phalanx of the halux or big toe.

This concludes the inventory of UMFC 12. As you can see, the individual was fairly intact when recovered by the authorities. However, there are some very important portions of the skeleton missing, such as the pubic and auricular surfaces of the coxal bones. Nonetheless, I was still able to do a fairly comprehensive forensic examination of the individual. Let us now take a look at the results of my forensic examination by first looking at sex determination.

Sex

Determining the sex of a skeletonized individual is obviously of great importance to forensic anthropologists and law enforcement authorities. In many cases, "when a skeleton is discovered during excavation or observed in a laboratory, one of the first questions asked is: is it male or female?" (Bass 1995: 25). One thing to keep in mind is that this question of sex refers to a person's biologically determined identity, not gender which is a "person's social identity"(White and Folkens 2000: 362). This difference can possibly be of interest to physical anthropologists if they are looking at the remains of a victim that was a transsexual or transvestite. For example, the skeletal evidence might show that the individual was a male, while the cultural materials found might point to a female.

Overall, determining the sex of individuals from skeletal material can be very accurate, at least in adults. White and Folkens (2000), point out that "the osteologist's starts with 50% accuracy-random guessing will be correct half of the time. For some elements, such as the cranium, training and experience can often allow correct sorting about 80-90% of the time"(White and Folkens 2000: 362). With children, these percentages go down. In fact, "the consensus is that any determination [of sex in sub-adults] is little better than a guess"(Bass 1995: 25). This is because the procedures used to determine sex are based on what are called "secondary characteristics" (Bass 1995: 25), or adult characteristics. These characteristics are ones that manifest themselves after the individual goes through the hormonal assaults associated with puberty. However, one should always keep in mind that there are going to be small gracile males and large robust females in every population, and "some populations are, on the average, composed of larger, heavier, more robust individuals of both sexes, and other populations are characterized by the opposite tendency" (White and Folkens 2000: 363). Therefore, forensic anthropologists "should always attempt to become familiar with the skeletal sexual dimorphism of the population from which unsexed material has been drawn" (White and Folkens 2000: 363). Keeping all these variables in mind will help forensic anthropologists come to a very reliable conclusion as to the sex of skeletal material.

There are many methods that can be used to determine sex from the human skeleton, many of which I will use in the analysis of UMFC 12. In general, sexing methods can be broken down into methods derived from the skull (non-metric cranial traits, discriminant function analysis, FORDISC), and post-cranial methods (measurements of the sacrum, sternum, scapula, clavicle, humerus, coxal, femur, and tibia, shape of the sacrum, shape of the sternum, shape of the scapula, shape of the pelvis). In my examination of UMFC 12 I attempted to use as many of these methods as possible, as long as the elements needed were available for examination.

Sex from the Skull

Non-metric cranial traits displayed on the skull are very good indicators of sex. In fact, "the skull probably is the second best area of the skeleton to use for determining sex" (Bass 1995: 85). What are these non-metric cranial traits? They are traits that manifest themselves differently on male and female skulls after puberty. They include traits such as the presence of brow ridges, mastoid size, chin shape, orbit shape etc. The skull that I examined from UMFC 12 was very well intact, which allowed me to analyze these traits in detail. Using a method that can be found in Dr. Randall Skelton's

Osteology lab manual that "has been found useful by several generations of students at the University of California-Davis" (Skelton 2002: 13), and a few generations here at the University of Montana-Missoula, I was able to determine that this individual was most likely a male. The skull exhibited a sunken nasal root (male trait), prominent brow ridges (male trait), an unsloping forehead (male trait), a fairly large and rugged mastoid process (male trait), a very rugged and robust nuchal area of the skull (male trait), square chin shape (male trait), ovoid orbit shape (ambiguous trait), dull or rounded orbit edges (male trait), medium zygomatic arch thickness (ambiguous trait), a fairly robust, thick mandible at the second molar (male trait), an angular robust gonial region of the mandible (male trait), and an average or medium palate size (ambiguous trait). Overall, the skull was only of average size, but it was very rugged and in some areas heavily muscle marked. This evidence points to a male individual. It should be noted that a lot of these traits are subjective in nature. How do you decide if the mastoid is small or large, rugged or smooth? The best way to do this is through the use of comparative skeletons, and through experience examining skeletons of all sizes and sexes. For example, non-metric cranial traits can be on a continuum from very rugged to smooth, and small to large. There are no distinct features that can be pointed to that separate the rugged from the not so rugged, or the smooth from the not so smooth. The best determination should rely on a combined analysis of all the traits listed above. I certainly would not classify an individual as male if a large rugged mastoid process was all I could base my determination on.

Sex from Discriminant Function

Giles and Elliot (1963) devised a method of sex determination from discriminant function analysis. According to these researchers, " the multivariate linear discriminant function can be looked upon as the solution of a multiple regression problem" (Giles and Elliot 1963: 54). So how does it work? This excerpt from Giles and Elliot (1963), explains it best:

"In the investigation at hand each sex was given an arbitrary value(0 for males, 1 for females) and sex was treated as an artificial variable. This artificial variable is taken as the dependent variable in a multiple regression where the anthropometric measurements form the independent variables. It is interesting to note that a variable which by itself has little discriminatory value may heighten the power of another. The final result is that the p measurements on an individual are replaced by a single measurement called a discriminant function score, which is arrived at by summing the p measurement, each weighted by the appropriate coefficient. These multiple regression coefficients, which form the discriminant function, were calculated on electronic computers according to a design expressed in Kendall (1957)" (Giles and Elliot 1963: 54-55).

There were a total of 21 discriminant functions devised by Giles and Elliot, some of which require 9 measurements, and some requiring as few as 4. More often than not, forensic anthropologists are faced with the prospect of analyzing fragmented material, so "the variations in the combinations of measurements employed should aid an investigator in finding a discriminant function that will fit the measurements possible on his specimen" (Giles and Elliot 1963: 59).

For the purpose of this study, I will use one of the discriminant functions devised by the authors in the examination of UMFC 12. Because I am going to be using FORDISC analysis (see Ancestry from FORDISC Analysis) which is a computer program that uses discriminant function analysis to determine both sex and "race" (ancestry), I will only use the discriminant function requiring 4 measurements at this time. FORDISC uses the 9 measurements proposed by Giles and Elliot, and then some, in its analysis, although it can give you results using only a few. Giles and Elliot's discriminant function using 4 measurements (number 16 in Giles and Elliot [1963: 60, Table 2]) can be shown in the following equation:

2.184 (g-op) + 1.00 (eu-eu) + 6.224 (zy-zy) +6.122 (po-ms) = [1495.40]

***From Giles and Elliot (1963: 60, Table 2)**

In the above equation, (g-op), (eu-eu), (zy-zy), and (po-ms) are all measurements that are taken from the skull. For example, (g-op) is the maximum length of the skull, while (eu-eu) is the maximum breadth (for a complete listing of measurements see appendices A and C). The number 1495.40 is the sectioning point between male and female. If the score is above 1495.40, then the skull is male, below 1495.40 and the skull is female. The following is the result of UMFC 12's analysis using discriminant function analysis:

2.184 (193) + 1.00 (137) + 6.224 (127) + 6.122 (28.8) = [1495.40]
421.512 + 137 + 790.448 + 176.316 = 1525.276
1525.276 is greater than 1495.40, Skull =Male

As you can see, UMFC 12's skull was determined to be male based on discriminant function number 16 in Giles and Elliot's 1963 article. Discriminant function scores have been under scrutiny by many forensic anthropologists of late. Overall, it is believed that the method used above is about 70% accurate (see table 3 Giles and Elliot (1963), Skelton Osteology Lab manual (Fall 1999)).

Sex from the Post-Cranial Skeleton

There are a number of methods that can be used to determine sex from the bones of the post-cranial skeleton. Probably the most important of all post-cranial elements used in sex determination is the pelvic girdle. In fact, "the entire pelvic structure has long been regarded as the most critical structure in the sexing of human skeletons" (Krogman and Iscan 1986: 200). This bone structure is very important, and like the bones of the skull, changes quite drastically when individuals hit puberty, even though "sexual dimorphism is present from fetal life" (Krogman and Iscan 1986: 200). Other bones of the post-cranial skeleton that can be used in the determination of sex include the sacrum, sternum, scapula, clavicle, humerus, coxal, femur and tibia.

Sex from the Clavicle

. This bone's accuracy in determining sex has been questioned by a number of anthropologists including Bill Bass who states that "the accuracy of estimating an individuals sex based on measurements of the clavicle has met with varying degrees of success" (Bass 1995: 133). Jit and Singh, in their study of clavicles from the peoples of India found that "the sex can be decided in 8 percent of male and 14 percent of female right clavicles and in 20 percent of male and 12 percent of female bones if the left clavicle is considered" (Jit and Singh: 1966: 570). One major study that was done on sexing was conducted by Thieme (1957) in which the clavicle was used as "one of a series of eight measurements to estimate sex" (Bass 1995: 133). A major drawback of this method is that it was conducted only on Negroid skeletons. Nonetheless, for lack of a better method, I will use the measurements I recorded from the right and left clavicle of UMFC 12 to determine sex based on Thiemes research as presented by Bass. (Bass 1995: 136). Using sliding calipers, I determined that the length of the right clavicle was 145.1 mm, while the left clavicle measured 150.6 mm. These measurements placed UMFC 12's right clavicle within the female range, and the left clavicle within the male range (when taking into account the standard deviations, see table 1 below).

(Table-1)

Measurement	Sex	N	Mean mm	Standard Deviation	Standard error of mean	Critical ratio (t)
Clavicle Length	M	98	158.24	10.06	1.158	13.90
	F	100	140.28	7.99	0.800	

*From Bass (1995), After Thieme (1957).

This can mean a number of things. As you will see in the pathology and trauma section of this paper, there is a rather large pathology that affected the proximal end of the right humerus. It is possible that this pathology may have affected the growth of the right clavicle. Also, it is possible that this individual was just small in nature and that is why even the left clavicle does not fall well within the male range of variation. Finally, it is possible that this individual was a female, although as you will see, I do not believe this is the case.

Sex from the Scapula

The scapula, or shoulder blade, is another element that can sometimes be used in sex determination. However, as is the case with UMFC 12, this bone is thin and fragile and often does not survive the taphonomic process, or recovery in one piece. There are two methods that can be used as indicators of sex from the scapula, the manubrium length between the superior and inferior angles, and the length of the glenoid cavity developed by Dwight" (Bass 1995: 125). Unfortunately, due to the fragmented nature of both the right and left scapulas of UMFC 12 I was unable to determine sex using manubrium length.

I was able to measure the length of the glenoid cavities of both the right and left scapulas with the following results: Right glenoid cavity length: 37.5 mm, Left glenoid cavity length: 37.6 mm. Plugging this information into table 2 below, it was determined that UMFC 12 fell squarely into the male category.

(Table 2)

Length	Females	Sex ?	Males
Glenoid Cavity Length	<34	34-36	>37

*From Bass (1995: 129)

There are other measurements that can be used to determine sex from the scapula, including maximum breadth, maximum length of spine, maximum width of crest of spine, etc. However, due to the condition of both scapulas I was not able to use any of these methods. This is unfortunate because it is believed that "the best dimension for sexual identification is scapular height" (Krogman and Iscan 1986: 228)

Sex from the Humerus

There are a number of methods that can be used to determine sex from the humerus. However, some researchers say that, "the humerus is a poor bone for sex estimation" (Bass 1995: 156). One method, the diameter of the head, could not be used on UMFC 12 because of heavy deterioration. Two methods that could be used were humerus length and epicondyle length as presented by Thieme (1957). However, as with his studies of clavicle lengths, this research was based only on Negroid skeletons, a population to which UMFC 12 was not believed to belong (see Ancestry section). In any case, for lack of a better method, Thieme's research was used in analyzing UMFC 12. Using an osteometric board, I was able to get the following measurements from both the left and right humerus. Humerus length: right 304 mm, left 321 mm. Epicondyle width: right 56.6 mm, left 58.6 mm. Using Thieme's results as shown in table 3, this individual would fall into the female/ ambiguous category of sex.

(Table 3)

Measurement	Sex	N	Mean	Standard deviation	Standard error of mean	Critical ratio (t)
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	

*From Bass (1995: 157), After Thieme (1957: 73).

All the measurements, except for the left humerus length, place the individual within the female range of variation. Again, this can be do to the pathology seen on the proximal right humerus (especially in the length of the right humerus), the possibility that we have a small individual, or the possibility that the individual is actually a female, which based on the overall analysis is unlikely.

Sex from the Coxal Bones

According to renowned forensic anthropologists Bill Bass, "the best area to determine the sex of a skeleton is the pelvis. The highest accuracy has been achieved using this bone" (Bass 1995: 208). Unfortunately, due to the fragmented nature of UMFC 12's pelvic girdle, I was unable to use all the methods available for sex determination from this important bone structure. However, some non-metric visual assessment methods were still able to be used. Like non-metric sex and race determinations made from the skull, the technique is very subjective To use it, you need a good skeletal collection for comparison and you need at least some experience looking at and comparing coxal bones from various sexes and age ranges. Below in table 4 you will see a list of traits that are used to visually determine sex from the coxal bones.

(Table 4)

Characteristic	Male	Female
Pelvis as a whole	massive, rugged, marked muscle sites	less massive, gracile smoother
Symphysis, sub-pubic Angle	higher, v-shaped	U-shaped, rounded broader, obtuse angle
Ischiopubic ramus ridge	ridge absent	ridge present
Obturator foramen	large ovoid in shape	Small, triangular in shape
Greater sciatic notch	smaller, close, narrow	larger, wider, shallow
Sub-pubic concavity	absent	present
Pubic bone	short and rounded	long and square
Auricular surface	flat	elevated
Acetabulum	relatively small	relatively large
Pelvic inlet shape	heart shaped	round or ovoid
Preauricular surface Sulcus presence and shape	absent or thin/ grooves	large, circular
Illium shape	high, vertical	lateral and divergent

* Characteristics taken from Bass (1995 209-216, Table 3-23), After Rogers and Saunders (1994: 1049, Table 1), Skelton (osteology lab manual), and Krogman and Iscan (1986: 209, Table 6.11).

Using the traits in table 4, I determined that UMFC 12 was most likely a male. Unfortunately, the sub-pubic angle, sub-pubic concavity, ischiopubic ramus, ventral arc, dorsal pubic bone, auricular surface height, preauricular sulcus shape, pelvic inlet shape, and obturator foramen shape could not be used in the analysis because of heavy wear and fragmentation (See pathology and trauma, inventory). However, the traits that were available for analysis appeared to be overwhelmingly male. The sciatic notch was very narrow, small, close, and deep, the illium shape was very high and vertical, the acetabulum was quite large, and the bones were heavily muscle marked along the illium and ischium portions that were available for analysis. This, along with a sacrum that appeared to be fairly narrow, leads me to conclude that the pelvis of UMFC 12 is most likely that of a male.

Sexing of the pelvis can also be done using the Ischium-Pubis Index. Developed by Washburn (1948) and presented by Bass (1995: 200), this method is done by measuring the pubis length and ischium length and plugging those numbers into the following formula:

$$\textbf{Ischium-Pubis Index} = \frac{\textbf{pubis length X 100}}{\textbf{Ischium length}}$$

Unfortunately, due to the condition of the coxal bones of UMFC 12, I was unable to use this method.

It is unfortunate that more of the pelvic girdle was not available for examination. I would be more comfortable in determining the sex of UMFC 12 if I were able to use more of the traits and methods noted above in my analysis. However, this is not uncommon in forensic cases. Often, an analysis of skeletal material will have to be done using fragmented or missing bones. Nonetheless, based on the limited number of traits available for analysis, I am confident that the coxal bones associated with UMFC 12 were from a male individual.

Sex from the Femur

Unlike the clavicle and the humerus, the femur has been studied extensively by generations of biological anthropologists. The "femur is one of the most-studied bones of the skeleton and as such has contributed a great deal to the literature on sex" (Bass 1995: 229). One method that can be used was devised by Pearson and presented in Bass (1995). This method uses four distinct measurements of the femur in determining sex. These include the vertical diameter, the popliteal length, the bicondylar width, and the trochanteric oblique length. Using an osteometric board and a pair of spreading calipers I was able to take all of these measurements using the left femur of UMFC 12. The first measurement, the vertical diameter, came out to be 43.5 mm. This measurement can be described as the diameter of the femoral head on a vertical plain, ***not*** horizontally. The second measurement taken was the popliteal length, which measured 140.2 mm, followed by the bicondylar width which measured 76.2 mm, and finally the trochanteric oblique length (the length of the bone from the proximal portion of the greater trochanter to the distal end of the femur) which measured 421 mm. Plugging these measurements into the results found by Pearson in his research showed the sex of UMFC 12 to be in the ambiguous to questionable male categories (see table 5 below). However, one thing to keep in mind about Pearson's method is that his measurements were taken on 17th

(Table 5)

	Female	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	72-76	74-76	76-78	>78
Trochanteric Oblique Length	<390	390-405	405-430	430-450	>450

*From Bass (1995: 230), After Pearson (1917-1919: Table 27).

century bones from London and that most modern populations are larger" (Bass 1995: 229-231). This fact has implications for this case. If modern populations are indeed larger as Bass says, this would push most of UMFC 12's measurements back down into the ambiguous category at least. We know from the background information that this individual probably lived some time ago, but probably not in the 17^{th} century. Most likely, this just shows that the individual was small in nature (see stature and weight).

Continuing on with the femur, the next method I used was actually a revision of Pearson's work done by Stewart (1979). This revision looked only at femoral head measurements (greatest diameter vs. vertical diameter in Pearson's study). Using a pair of sliding calipers I determined that the greatest diameter of the left femoral head of UMFC 12 was 43.7 mm. Using Stewarts research presented in table 6 below, it was determined that UMFC 12's sex fell into the sex indeterminate, or ambiguous category.

(Table 6)

Female	Female ?	Sex Indeterminate	Male?	Male
<42.5	42.5-43.5	43.5-46.5	46.5-47.5	>47.5

*From Bass (1995: 231)

One thing to keep in mind regarding these methods (Pearson and Stewart), is that they were developed using Caucasoid skeletal material as opposed to Thieme's work which was based on Negroid skeletal material. This is important because UMFC 12 was most likely Caucasoid (see race/ancestry section of the paper). Therefore, I will not use Thieme's method of sex determination from the femur because there are better methods available to use in sexing the femur. If I was dealing with a possible Negroid skeleton I would have used Thieme's work.

Sex from the Tibia

Bass presents a method for sex determination from the tibia developed by Symes and Jantz (1983) on pages 247-250 of his book. This method which Bass describes as "accurate", is done by comparing three distinct measurements (proximal breadth, distal breadth, and circumference at the nutrient foramen) to determine sex. There work is shown in table 7 below.

(Table 7)

Group	**Proximal breadth**	**Distal breadth**	**Circumference at nutrient foramen**
Whites			
Sectioning point	75.11	49.24	90.16
Male mean	79.56	52.23	95.97
Female mean	70.66	46.24	84.34

*From Bass (1995: 250, Table 3-37), After Symes and Jantz (1983)

For UMFC 12 I got the following measurements from the left tibia: proximal breadth 73.7mm, distal breadth 52 mm, and circumference at nutrient foramen 93 mm. Comparing these numbers to the chart above shows that the proximal breadth falls on the female side of the sectioning point, while the distal breadth and circumference at the nutrient foramen measurements fall on the male sides of the sectioning points. Therefore, overall I would say that this individual was male.

Sex from the Sacrum

The sacrum, which by definition is actually part of the pelvic girdle, is an element that can be very useful in sex determination. This bone has been studied extensively by biological anthropologists "because of its contribution to the pelvic girdle and in turn to the functional difference in the region between the sexes" (Krogman and Iscan 1986: 224). In general, the sacrum is "more curved in males and flatter in females" (Bass 1995: 113). Also, in females, "the width of the first sacral body (articular area) is equal in width to each ala" (Bass 1995: 113). In the case of UMFC 12, I was unable to determine if any of these traits existed. The sacrum of this individual was in two pieces, broken off at the right ala. The body was missing completely, having been broken off just superior to the first sacral foramen. If I were to glean any useful information regarding sex from the sacrum of UMFC 12, it would be that the portion present appears to be fairly narrow, a male trait according to Rogers and Saunders as presented in Bass (1995) on page 216.

Sex from the Sternum

As with the sacrum, the sternum of UMFC 12 was too fragmentary to be of use in sex determination. For most determinations of sex from the sternum you need to be able to analyze and measure the manubrium, which was missing from this specimen. For example, "the body of the sternum in males is more than twice the length of the manubrium" (Bass 1995: 117). One item of interest involving the sternum and sex determination was the presence of a sternal foramen measuring 8.4 mm by 14.6 mm. Sternal foramina as a rule, do not occur in "individuals younger than 20 years of age, but occurred at all later ages to the extremes of life and were about twice as common in men as in women, occurring in 9.6% and 4.3% respectively" (McCormick 1981: 249-252).

Conclusions on Sex

Using a multifactorial approach, I am confident that the individual that makes up UMFC 12 is indeed a male. I would be more confident in this conclusion if I had more of the pelvic girdle available for analysis. However, the majority of the evidence points towards a male individual. The evidence from the skull is overwhelming. Almost every trait noted fell into the male category with only a few falling into the ambiguous or sex indeterminate category. Also, if you look at the skeleton as whole, it is very muscle marked from the skull right down to the tibias. Some doubt is cast on this determination if you look at the sex estimates based on the long bones. The methods used on the humerus, femurs and tibias all put the sex of the individual somewhere in the possible female/ sex indeterminate/ possible male categories, with a few methods falling into the solidly male or female categories (see distal breadth of right tibia, length of right humerus above). However, the female results could have easily been a result of the small stature of the individual (as you will see in the stature and weight section of this paper), and possibly by the pathology and trauma exhibited on the proximal end of the right humerus. Overall, I believe that the evidence exhibited by UMFC 12 yields a high probability that this individual was indeed male.

Race/ Ancestry Determination

Determining race, or ancestry, is a very difficult task for forensic anthropologists. Many biological anthropologists today would find it difficult to prove, or even argue that there are distinct, clear-cut "races" of human beings. If you look at the variations in skin color found throughout the world, you will notice that they present a continuum from very light to very dark, with nearly every shade possible in between. Therefore, forensic anthropologists find it difficult to classify an individual into one of the three conventional categories (Caucasoid, Negroid, and Mongoloid), based on only skeletal material. Biologically, this is nearly impossible, instead "most of the world recognizes race through the veil of culture. The lines between major racial groups are drawn differently by each cultural group. To some, skin color is all important, while to others, hair type, eye shape, nose size, or lip form is more important" (Burns 1999: 153). Nonetheless, when the police bring a case to forensic anthropologists, race is one of the key factors that they ask to be determined in order for a proper identification to be made. When a missing persons report is filed with police, more than likely there will be a section showing the persons race included. Therefore, forensic anthropologists must oblige the police by making some type of racial determination. In the U.S.A., from the point of view of forensic anthropologists, we are divided into three broad racial groups, African American, Asian and Native American, and White, which are usually referred to as Negroid, Mongoloid, and Caucasoid, respectively. For the purposes of this paper I will use the categories European Ancestry, African Ancestry, and Asian Ancestry. Individuals of European ancestry will encompass those which commonly fell into the "Caucasoid" or "white" categories, while individuals of African ancestry will encompass those that commonly fell into the “Negroid” or “black” categories. Categorizing those of Asian Ancestry is a bit more difficult, for this paper I will use it as meaning to encompass both Native American individuals and peoples from the actual continent of Asia.

When determining race or ancestry, there are a number of methods that can be used. First and foremost, the skull can be a diagnostic area. In fact Bass makes the argument that “the skull is the only area of the skeleton from which an accurate estimation of racial origin may be obtained” (Bass 1995: 86). However, as you will see, other means of race determination have been researched. Both metric and non-metric methods of racial determination can be done using the bones of the skull, and both were used in the examination of UMFC 12.

Non-Metric Racial Determination from the Skull

Non-metric, or morphological differences in the skull are one way that forensic anthropologists determine race from skeletal material. In table 8, below, you will find the traits that are commonly used by forensic anthropologists to determine race:

(Table 8)

Non-Metric Cranial Racial Traits

Trait	Mongoloid	Caucasoid	Negroid
Skull length	long to short	long to short	mostly long
Skull breadth	broad	narrow to broad	narrow
Skull height	medium	high	low
Coronal contour	round	long to round	long
Sagittal contour	arched	round	flat
Face projection	not projecting	nose projects	jaws project
Frontal bossing	females only	females only	both sexes

Face Breadth	broad	narrow	narrow
Face Height	high	high to medium	low to medium
Zygomatics	robust and flaring	small, retreating	small, retreating
Nasal orifice width	medium	narrow (height = 2x width)	wide (height = width)
Orbit Shape	rounded	angular to round	rectangular
Interorbital distance	medium	narrow	wide
Nasal bones width	medium	narrow	wide
Nasal sill	intermediate	sharp	smooth
Ruggedness	medium	gracile	rugged
Incisors	shovel-shaped	blade-form	blade-form
Profile	moderate alveolar prognathism	little prognathism, orthognathic	strong alveolar prognathism
Palatal shape	elliptic	parabolic	hyperbolic
Palatal suture	straight	Z-shaped	arched

*From Burns (1999: 154, table 12.4), Skelton (Fall 1999 Osteology Manual: 18), Bass (1995: 86-92)

Keeping table 8 in mind, UMFC 12 showed the following non-metric cranial racial traits: skull length; medium to short (European and Asian ancestry), skull breadth; medium (European Ancestry trait), skull height; high (European ancestry), coronal contour; arched (Asian ancestry), sagittal contour; round (European ancestry), frontal bossing; not present (not African ancestry), face breadth; narrow (European ancestry), face height; high (European or Asian ancestry), face projection; nose projects (European ancestry), zygomas; strong back taper (European ancestry), interorbital distance; fairly narrow (Asian or European ancestry), orbit shape; angular to round (European ancestry), nasal orifice width; narrow, orifice measures 19.6mm by 37.5 mm, (European ancestry), nasal bone width; narrow (European ancestry), nasal sill; present, very strong, sharp (European ancestry), palate shape; parabolic (European ancestry), palatal suture; Z-shaped (European ancestry), ruggedness; medium (Asian ancestry), profile; little prognathism, orthognathic (European ancestry), and incisors; blade form (European or African Ancestry).

In general, skeletal remains are classified as belonging to the race indicated by the majority of the traits present. UMFC 12 can therefore, be comfortably placed into the racial category of European ancestry or "Caucasoid". Of the twenty traits listed in table 8, this individual scored as of European ancestry for eighteen of them. In this regard, we were fortunate, because this is not often the case. It is not uncommon for the race section of a forensic report to say that the individual was of ambiguous ancestry, which basically means that race cannot be determined. Overall, even though Bass (1995) makes the statement that the skull is the only reliable way to determine race from skeletal material, in fact "this method is not extremely reliable, probably between 50%-75% accuracy can be expected" (Skelton 1999: 17). Moving on, let us now take a look at some procedures to determine race from the skull using measurements (anthropometric methods).

Race Determination Using Anthropometric Methods

Determining race from discriminant function analysis has been in use for some time. These methods use measurements of the skull (see appendix C) to determine racial affinity. There are a number of ways this can be done, from the Giles and Elliot (1962) method, to Gill's interorbital features method (1984), to FORDISC analysis. All these methods were used to determine the race of the individual making up UMFC 12.

Giles and Elliot Discriminant Function Method

To complete this method you first need to get a number of measurements from the skull and plug them into two discriminant function equations. Once the discriminant score has been determined you plot the score on a 2-dimensional graph which separates the scores into either European ancestry, or "White", African ancestry or "Black", or Asian ancestry or "Indian". To begin, I took the following measurements from the skull of UMFC 12: basthion-prosthion height (ba-pr); 94 mm, glabella-occipital height (g-op); 193 mm, maximum width (eu-eu); 146 mm, basion bregma (ba-b); 133 mm , maximum diameter (Bi-zygomatic, zy-zy); 136 mm, prosthion-nasion (pr-n); 66.7 mm, and nasal width (al-al); 21.1 mm (see appendix A). These measurements were used to calculate scores on the White/Black scale and the White Indian scale, using the coefficients presented in table 9.

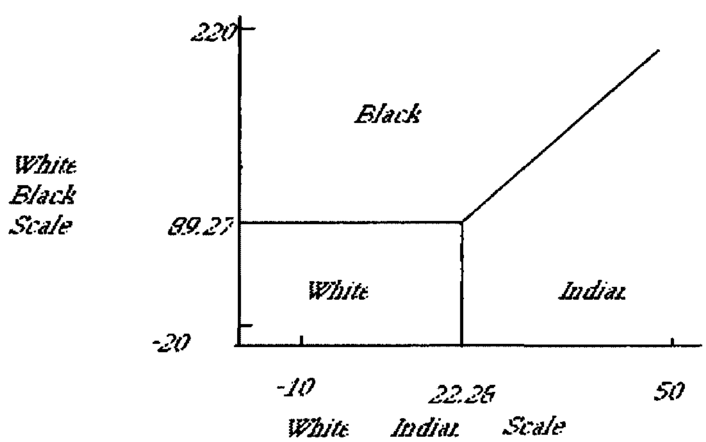
(Table 9)

		White/Black		White/Indian
1) Basion-Prosthion	x	+3.06	x	+.10
2) Glabella-Occipital	x	+1.60	x	-.25
3) Maximum Width	x	-1.90	x	-1.56
4) Basion-Bregma	x	-1.79	x	+.73
5) Basion-Nasion	x	-4.41	x	-.29
6) Maximum Diameter	x	-.10	x	+1.75
7) Prosthion-Nasion	x	+2.59	x	-.16
8) Nasal Width	x	+10.56	x	-.84
Total:				

*From Bass (1995: 94)

The following scores were obtained: European/ African ancestry scale; -2.731, European/Asian ancestry scale 8.614. Plotting these scores on the graph shown in table 10, it is clear that this individual falls within the European ancestry range. Table 10 shows that the sectioning point between European ancestry and African ancestry is 89.27, and UMFC's score of -2.737 is below this value placing it in the European ancestry range. The sectioning point between European ancestry and Asian ancestry is 22.8, and UMFC 12's score of 8.614 is less than this, placing it in the European ancestry range. Therefore, it is determined that UMFC 12 was most likely of European ancestry.

(Table 10)



*From Bass (1995: 94)

Gill's Interorbital Features Method

The next method I used is called Gill's interorbital features method. The author notes that one of the main reasons he developed the method was because "for years a human identification problem has existed in the northwestern Great Plains of North America in distinguishing the skeletal remains of Whites from those of Native American Indians" (Gill 1984: 329). This method only applies to the case of distinguishing those of European ancestry from those of Asian ancestry, in this case Native Americans. This method involves first taking six measurements; the maxillofrontal breadth, the naso-maxillofrontal subtense, the mid-orbital breadth, the naso-zygoorbital subtense, the alpha chord, and the naso-alpha subtense. The subtense measurements are taken with a type of specialized calipers called a simometer which "were constructed at the University of Wyoming according to the Howells plan" (Gill 1984: 330). The maxillo-frontal breadth, mid-orbital breadth, and the alpha chord are all simple measurements. The first is the distance across the bridge of the nose from the superior border of the left lacrimal to the superior border of the right lacrimal. The second measurement, mid-orbital breadth, is "the breadth between zygoorbitale left and right" (Gill 1984: 337), which can be defined as the spot on the face where the zygomaxillary suture meets the eye orbit. The last of this first group of measurements is probably the most complex of the three. The alpha cord is "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 the zygoorbitale" (Gill 1984: 337). This measurement requires some sort of straight edge (a ruler works fine) which is placed on the tangent described above. Then you have to turn the skull to an angle in which you can see between the straight edge and the skull. At the deepest point of this tangent make a mark in chalk. Do this on both sides and then measure the breadth between them. This is the alpha chord. The naso-maxillary subtense, naso zygoorbital subtense, and naso-alpha subtense have to be measured using a simometer. Basically they are measurements of how high the lowest point along the nasal bridge is above the maxillofrontal breadth measurement (naso-maxillofrontal subtense), the mid-orbital breadth (naso-zygoorbitale subtense), and the alpha chord (naso-alpha subtense). Once you have taken all six of these measurements, the next step is to plug them into a set of formulas to calculate three indices:

1) naso-maxillo frontal subtense ÷ maxillofrontal breadth X 100
2) naso-zygoorbital subtense ÷ zygoorbital breadth X 100
3) naso-alpha subtense ÷ alpha chord X 100

Finally, the values for the three indices are compared to sectioning points between Asian ancestry and European ancestry. The sectioning point for index 1 is 40, for index 2 it is 40, and for index 3 it is 60. If the calculated value falls above the sectioning point then the individual would be considered of European ancestry, and below the sectioning point they would be considered of Asian ancestry. Keep in mind this method can only be used when the classification African ancestry has been ruled out.

The following measurements and calculations were done using the rules I described above:

1) (naso-maxillofrontal subtense) 8.6 ÷ (maxillofrontal breadth) 19.5 X 100 = $\boxed{\textit{44.1}}$
2) (naso-zygoorbital subtense) 22.6 ÷ (zygoorbital breadth) 45 X 100 = $\boxed{\textit{50.2}}$
3) (naso-alpha subtense) 20.2 ÷ (alpha chord) 31.2 X 100 = $\boxed{\textit{64.7}}$

These results indicate that UMFC 12 was of European ancestry. All three of the indices fell above the determined sectioning points noted above.

Overall, the accuracy of this method has been questioned by some anthropologists. However, Gill points out that although "none of the three indices by itself produces more than about 80% accuracy in separating American Indians from whites, by using all three in conjunction (a simple two-out-of-three notation) Bennet was able correctly to classify slightly 90% of her sample [of 195 individuals]" (Gill 1984: 331). This is an incredible rate of accuracy where race is concerned. It's usefulness in determining race in a forensic context where any number of possible racial affinities, and racial mixtures are possible, has not been fully determined, because how individuals of African ancestry score with respect to the sectioning points has not been investigated. In the case of UMFC 12, I believe this method can be of some use. There is no real evidence showing that this individual was of African ancestry, which in the narrow parameters that we have to work with makes him either of Asian or European ancestry. Asian ancestry of course can mean Native Americans, Asians, etc. These groups are very similar skeletally, which means that Gill's method may indeed be of some use in regards to UMFC 12. However, I would certainly never base my racial determination on only one method such as Gill's. A determination should always be based on a multifactorial approach. The more applicable methods used the better. Keeping this in mind lets move onto the next method used on UMFC 12 to determine race.

FORDISC Analysis

FORDISC analysis uses discriminant functions calculated by a computer program to determine the race and sex of skeletal material. The use of this method allows the researcher to "conduct a craniometric analysis of two to eleven groups, using one to thirty-four measurements" (Ousley and Jantz 1996: 1). The developers of this method do note that caution should be used when applying this method. In particular, they say that the FORDISC program will have difficulty analyzing individuals whose race or ancestry is not represented in their reference samples, (racial) hybrid groups of people, (racial) hybrid individuals, remains affected by disease, disuse, treatment, or trauma, non-adults, and archaeological populations (Ousley and Jantz 1996: 2). Using discriminant function analysis, the program provides two sets of statistics to researchers, a posterior probability of membership in each group, and a typicality probability for each group. The posterior probability "evaluates the probability of group membership under the assumption that the unknown belongs to one of the groups in the function" (Ousley and Jantz 1996: 4). Typicality probability represents "how likely the unknown belongs to any particular group, based on the average variability of all groups in an analysis" (Ousley and Jantz 1996: 7).

In the case of UMFC 12, the cranial measurements shown in appendix A were those used in the FORDISC analysis. From this program, it was determined that this individual was of European Ancestry with a posterior probability of .618, and typicality probability of .021 (see table 11). It should be emphasized that caution must be applied when using this method of race/ ancestry and sex determination. As with most other methods, it is better to take a multifactorial approach whenever possible. I would not, with any amount of confidence, base my sex and race determination on a case from FORDISC analysis alone.

Race From Visual Assessment of the Sacrum

Unfortunately, due to the fragmented nature off the sacrum, this method of race determination was not possible. It is normally done by calculating the sacral index which is the maximum anterior breadth X 100 divided by the maximum anterior height.

Discriminant function results using 16 variables:
GOL XCB ZYB BBH BNL BPL MAB UFHT WFB NLH NLB OBB
OBH FRC PAC OCC

Group	Total Number	WM	Into Group WF	BM	BF	AM	AF	JM	JF	HM	CHM	VM	Percent Correct
WM	171	129	16	1	0	3	1	5	0	8	8	0	75.4 %
WF	135	10	111	0	2	0	1	0	6	4	0	1	82.2 %
BM	125	7	1	71	15	2	4	8	2	11	3	1	56.8 %
BF	107	1	4	11	79	0	1	0	9	2	0	0	73.8 %
AM	46	0	0	0	0	34	3	2	2	0	4	1	73.9 %
AF	28	0	1	1	0	3	16	0	2	2	1	2	57.1 %
JM	100	2	0	6	1	7	2	48	10	9	11	4	48.0 %
JF	100	1	6	1	9	0	3	6	60	3	4	7	60.0 %
HM	37	4	0	5	2	1	2	2	0	16	4	1	43.2 %
CHM	79	1	0	7	0	1	6	5	2	4	50	3	63.3 %
VM	51	0	0	0	0	0	0	2	1	1	5	42	82.4 %
Total:	979				Correct:	656							67.0 %

Multigroup Classification of UMFC #12

Group	Classified into	Distance from	Probabilities Posterior	Typicality
WM	** WM **	29.4	.618	.021
WF		30.4	.374	.016
BM		46.1	.000	.000
BF		48.2	.000	.000
AM		49.5	.000	.000
AF		40.3	.003	.001
JM		41.8	.001	.000
JF		46.4	.000	.000
HM		39.3	.004	.001
CHM		51.4	.000	.000
VM		62.5	.000	.000

UMFC #12 is closest to WMs

UMFC #12		WM 171	WF 135	BM 125	BF 107	Group Means AM 46	AF 28	JM 100	JF 100	HM 37	CHM 79	VM 51
GOL	193	187.8	177.7	186.7	178.5	179.9	177.6	180.1	171.7	179.7	180.8	172.1
XCB	137	141.0	135.9	137.3	133.6	143.0	137.9	140.9	136.4	138.1	139.4	140.6
ZYB	127	130.5	120.8	131.1	122.7	142.0	132.5	134.0	125.1	129.1	133.3	130.0
BBH	133	141.7	133.5	133.9	127.5	132.9	129.4	137.8	131.7	136.2	139.2	137.5
BNL	109	105.9	98.5	102.5	96.9	103.2	99.8	101.5	95.5	101.6	100.0	97.5
BPL	89	97.0	90.9	103.1	98.4	100.7	96.9	99.1	94.3	97.5	97.9	96.4
MAB	59	62.1	57.9	66.9	63.2	66.5	63.2	66.1	61.5	64.5	65.5	66.2
UFHT	66	71.7	66.9	72.9	68.0	73.8	71.0	70.6	65.8	73.2	72.3	71.4
WFB	93	97.5	93.5	96.9	93.8	97.1	92.1	93.2	89.7	94.4	92.7	94.6
NLH	53	52.6	49.3	51.7	48.0	54.0	51.9	52.5	48.7	52.9	52.4	53.0
NLB	21	23.7	22.3	26.0	24.8	26.0	25.5	25.4	24.8	24.4	25.9	26.2
OBB	40	40.3	38.3	39.7	37.7	42.9	41.0	39.6	38.1	38.8	40.7	40.4
OBH	38	33.4	33.3	34.5	34.4	35.4	35.1	34.9	34.2	34.6	34.2	33.8
FRC	113	114.3	108.6	111.8	106.8	110.7	108.0	111.6	106.4	111.1	112.7	111.9
PAC	118	117.8	113.3	118.0	113.7	109.5	108.1	112.0	108.7	112.2	115.5	110.1
OCC	99	99.9	96.5	96.8	94.4	93.8	93.6	100.5	97.4	96.5	98.0	98.5

(Table 11) Shows the results of FORDISC 2.0 Analysis on UMFC 12

Race From Visual Assessment of the Scapula

These bones were also too fragmented to be used in the determination of race. This method requires that the following dimensions and indices be determined: total height, infraspineous height, breadth, and the scapular index which is the maximum breadth X 100 divided by the maximum length.

Race From Visual; Assessment of the Femur

There are a number of methods that can be used to determine race from the femur. Unfortunately due to equipment restraints, a couple of the methods, intercondylar shelf angle (Craig 1995), and anterior femoral curvature (Stewart 1962), were unable to be done. One method that was used actually comes from Stewart's (1962) research, although it has nothing to do with femoral curvature. In his research, he also used the greater Trochanter-lateral condyle length. He gave the following ranges (table 12) that can be used for racial determination from the femur:

(Table 12)

Measurement or Index	Racial group	Mean	Standard deviation	Range
Greater Trochanter-Lateral condyle length	Negroid	450.6	24.1	411-500
	Caucasoid	426.2	20.2	383-474
	Mongoloid	433.3	18.9	404-482

*From Bass (1995: 236, Table 3-33)

The measurement that I was able to take from UMFC 12's left femur was 402 mm, which shows that this individual falls into the Caucasoid or European ancestry range. As you can see in the table above, the range for individual of European ancestry was 383-474, the only range that UMFC 12 fit into. Determination, from this method: European ancestry.

Race From Visual Assessment of the Teeth

The teeth of this specimen were also examined in an attempt to determine race. In particular, I was able to use the cusp patterns on the lower molars in making my determination. Bass (1995) defines terms for the cusp patterns in humans. He says that "the mandibular molars normally display either 4 or 5 cusps. These cusps are arranged so that the grooves between them form either a "T" or a "Y"". (Bass 1995: 293). What this means is that there are four possible classifications for mandibular or lower molars, Y5, +5, Y4, and +4. To determine the race of UMFC 12 from the teeth, I had to classify the molar cusp pattern and then determine which racial affiliation had the highest frequency of that pattern.

To begin, I will look at the lower 3rd left molar. This molar showed the Y4 pattern, however, "the genetically unstable 3rd molar frequently presents an irregular cusp pattern that does not resemble any particular type" (Bass 1995: 294). Nevertheless, this pattern, according to Dahlberg (1951) is seen most frequently in ancient European Whites (11%), and E.G. Eskimos (11%), followed by Texas Indians (6.6%) (Bass: 295, table 4-4).

Next I looked at the lower right 1st molar. This tooth displays the Y5 pattern. Bass says that the "genetically stable 1st mandibular molar most frequently displays the ancestral Y5 pattern (Bass 1995: 293). This pattern is so frequent I do not believe it is of much use in race determination. For example, according to Dahlberg, it can be seen in

100% of the Chinese, Australian Aborigine and Mongol specimens examined (total of 47 individuals), and 87% of European white males. The lowest frequency was found in Texas Indians (68.7%) (Bass 1995: 294, table 4-2). Because the Y5 pattern is seen in such a high frequency among almost all populations of the world, I do not believe it is a very good indicator of race. You can make the argument that because UMFC 12 has the Y5 pattern, he is most likely Mongolian or Chinese. However, remember nearly 9 out of 10 European Whites in Dahlberg's study have this pattern as well.

Other indicators of race from teeth include the shoveling phenomenon seen in the incisors, and Carabelli's cusp. According to Bass, Carabellis cusp is not seen very often in modern populations, "except in one population of 80 Pima Indians, in which 37 displayed the cusp" (Bass 1995: 295). UMFC 12 did not display this cusp. Shoveled incisors are a phenomenon that is important because of "it's relatively high frequency of occurrence in Mongoloid racial groups" (Bass 1995 : 297). Again, UMFC did not show this trait.

Overall, it could be argued that this individuals teeth are at least consistent with someone of European ancestry. The individual did not display any of the characteristics (shoveled incisors, Carabelli's cusp), associated with populations of Asian ancestry (Mongoloid). Also, the cusp patterns displayed by the lower left 3rd, and lower right 1st molars are consistent with those of people of European ancestry.

Conclusions on Race

Overall, I believe that this individual was of European ancestry. The skull of the individual was overwhelmingly of European ancestry in morphological appearance. This assessment was backed up by European ancestry (Caucasoid) scores using Giles and Elliot's discriminant function analysis, FORDISC, and Gill's interorbital method. Also, visual analysis of the teeth, and anthropometric analysis of the femur showed likely European ancestry, although these methods are probably not as strong of indicators as the others used.

Age Assessment

There are many ways to determine age from the human skeleton. In fact, "entire books have been and could be written exclusively on age estimation" (Bass 1995: 12). Most aging methods are based on either degenerative changes on and in the bones, and growth of the bones. Overall, age estimation can be very accurate, especially in young adults and children "when teeth are erupting and the epiphysis uniting" (Bass 1995: 12). In adults, the estimation of age can still be very accurate, although degenerative changes (what most adult age estimations are based on), are less predictable than human development and growth (what most young adult and children age estimations are based on). Overall, adult age ranges from skeletal material will be much wider, and less precise. Even though age estimation has been shown to be accurate in studies, there still are some potential problems which must be kept in mind. For example, "even under "normal" and developmentally uneventful conditions, the rates at which various components of one individual may grow and take shape, erupt or fuse, or become obliterated and incorporated into a larger whole may vary conspicuously from individual to individual of the same sex as well as between individuals of different sexes" (Schwartz 1995: 185). Also, a person's lifestyle can have a huge impact on the degenerative changes in the skeleton, "one must always bear in mind that individual life histories complicate the task of determining age at death" (Schwartz 1995: 185). Notwithstanding these possible problems, an age determination is still very important, especially to police trying to make an identification. Even if we are able to narrow the age range of the individual to within 30 years it can still sometimes be very helpful. Keeping the benefits and drawbacks of age determination in mind, let us now take a look at the methods that were applied to UMFC 12.

Age From Dental Attrition

The first set of methods that I will look at is age from dental attrition. This method of aging has been studied and developed by many researchers. The first method that I will examine was developed by Brothwell in 1965, and was based on "wear patterns on premedieval British teeth" (Bass 1995: 301). Applying this method to skeletal remains is fairly simple. You simply compare the wear pattern displayed on the teeth of the individual you are studying with the charts developed by Brothwell showing the different wear patterns and their corresponding ages for all the different teeth in the mouth of adults. Overall, the accuracy of this method has been questioned. It can be said that "unfortunately, all the dentition within the population do not wear at the same rate because of the individual differences in diet and tooth structure. This severely limits the accuracy of age estimation by this method, and other criteria should be consulted whenever possible" (Bass 1995: 300-301). Nonetheless, let us now take a look at the results from the analysis of the teeth of UMFC 12.

In total, there were 4 teeth that were examined for this procedure; the upper 2nd left molar, the upper 1st right molar, the lower 3rd left molar, and the lower 1st right molar. The upper 2nd left molar fit into the 25-55 years age range. (see Brothwell 1965: 69, Fig. 30). The wear on this tooth can be best described as slight dentin exposure on all the cusps. It was determined that the upper 1st right molar would also fit into the 25-55 years old range. There is dentin exposure on all cusps that is so severe that it connects on both lingual cusps. Now looking at the lower 3rd left molar, again, it was determined that the tooth wear was consistent with the age range of 25-55 years old. There is severe dentin exposure on two of the four cusps. Finally, an examination of the lower 1st right molar once again showed an age range of 25-55. There is dentin exposure on all four cusps, and this exposure is starting to connect across the distal cusps of the tooth.

Overall, this examination gives us an age range of 25-55 years old at the time of death of the individual. Again, we should not base our age determination on just one method, especially dental attrition because of the problems I mentioned above.

Tromley's (1996) dental attrition method is of interest because it was developed using skeletal material from the state of Montana. Again, this method is used by comparing the wear pattern of the teeth of the individual under study to a chart that shows and describes different wear patterns and their corresponding age ranges. The first teeth that I analyzed from UMFC 12 were the lower right 1st and 2nd incisors, and the lower left 1st and 2nd incisors. Using the corresponding chart showing tooth wear it was determined that the teeth scored as level 5 wear. This put the age at 35+. Next, the lower left and right canines were examined and they were scored as level 3-4 wear. This gave a corresponding age range of 26-47 years old. Moving distally on the lower jaw, the next teeth analyzed were the lower left 1st and 2nd premolar. These teeth were scored as in stages 2, and 3 which would give the individual and age of 22-44 years. The lower right 1st and 2nd premolars were scored next and it was determined that they fell into category 2 which would give them a corresponding age of 22-34 years. Moving away from the lower jaw, the next tooth I looked at was the upper left canine which was scored as level 4 wear. This gives a corresponding age of 30-37 years old. The next tooth examined was the upper left 2nd molar which showed level 4-5 wear. This gives a corresponding age of 30+ years. Finally, the last tooth assessed was the upper right 1st molar which was scored as level 5-6 wear. This gave me a corresponding age of 35+. From these scores and corresponding age ranges, I was able to come up with a narrow and wide age at death estimation for UMFC 12. The wide range is determined by simply taking the youngest possible age determined by tooth wear (in this case 26), and the oldest possible age (in this case 47). In doing this I determined the wide age at death estimation for UMFC 12 is ***26-47*** years old. This is a bit narrower than the age that was determined by the Brothwell method and is still fairly wide. To determine the narrow range, the following ages were used. For the lower spectrum of the narrow age at death estimation I used 35 years. This was used based on the examination of the lower right 1st and 2nd incisors, and the lower left 1st and 2nd incisors, which showed that the individual was at least 35+ years old. So in theory, the individual making up UMFC 12 should have been at least 35 years old when they died. To determine the high age on the narrow age range spectrum we look at the score derived from the examination of the upper left canine. This tooth gave us a possible age range of 30-37 years old at the time of death. Which in theory would mean that the individual was no older than 37 when they died. Using these scores then, it was determined that the possible narrow age range for UMFC 12 at the time of death was ***35-37*** years of age.

As with Brothwell's method, I would not use Tromley's method of age determination at the time of death as the only indicator of age when examining human remains. In particular I would be cautious in using the narrow age range that was determined with much confidence. Instead, these ranges when at all possible should be used in conjunction with other methods of age at death estimation in a multifactorial approach.

Age From Cranial Suture Closing

Another method of age at death estimation that has received a lot of attention is cranial suture closure. In fact, "of all age indicators, cranial sutures have been the most widely used because they are easy to examine and skulls from archaeological excavations are often dealt with separately from other bones" (Masset 1989: 71). Cranial suture closure can be a very helpful diagnostic age determiner in some forensic cases. However, there are some problems, most notably, the fragility of the skull and the accuracy of the methods in general. The skull is composed of a number of very thin bones that often do not hold up well after death. There are a number of taphonomic processes (see pathology and trauma) that can seriously harm a skull that is buried in the ground or exposed to the elements. Nonetheless, regardless of the problems sometimes associated with age determination from suture closure, I still used them in the analysis of UMFC 12. As with any method of age determination I most certainly would not base my conclusions regarding age on one method. This rule holds true with suture closure as well.

The first method of age determination from cranial suture closure that I used was the Todd and Lyon ectocranial suture method as presented in Dr. Randall Skelton's Osteology lab manual (Fall 1999). As with most suture closure methods, this procedure requires that the analyst score the sutures as either ***open*** (the suture is completely open, with no closure at all along the whole length of the suture), ***commenced*** (the suture has closed, or been filled with bone in at least one section along the length of the suture.

However, there are still open sections), and ***terminated*** (the suture has closed along the whole length. The suture is no longer visible) (Skelton, Fall 1999: 11). The sutures that get analyzed using this method are the sagittal (which runs along the top of the skull from front to back), the coronal (which runs across the top of the skull from side to side), the lambdoidal (which runs from side to side across the back of the skull), the masto-occipito (which runs along the border between the occipital bone and the mastoid process of the temporal bone), and the spheno temporal (which runs along the border of the sphenoid bone and the temporal bone on the right and left sides of the skull). The following chart shows the sutures and the ages corresponding to degree of closure. This table is for the ectocranial sutures (sutures visible from the outside of the skull).

(Table 13)

Suture	Commencement	Termination
Sagittal	20	29
Coronal	26	50
Lambdoidal	26	31
Masto-occipito	28	32
Spheno-temporal	36	Never

*From Skelton (Fall 1999: 11)

Keeping the chart above in mind, let us now take a look at how the sutures from UMFC 12 scored using the Todd and Lyon method. The sagittal suture from this individual was commenced. Looking at the chart above we notice that this usually occurs by 20 years of age. However, this suture was ***not*** terminated, which tells us that this person was most likely younger than 29. Determination: 20-29 years of age. Moving on, the coronal suture was also scored as commenced, which would put the individual age at 26-50 years of age. The lambdoidal suture was also commenced, as was the masto-occipito. This would give us corresponding ages of 26-31 years and 28-32 years of age respectively. The right spheno-temporal suture was open, however, it appears that this may have occurred because of a taphonomic process such as intense soil pressure, which could have "popped" the suture open. The left spheno-temporal suture could not be used because the temporal bone had become disarticulated from the skull. Overall, using the Todd and Lyon method gave a wide age at death estimation of ***20-50*** years old, and a narrow age estimation of ***26-31***.

The next method used was the Todd and Lyon (From Skelton 1999) endocranial (sutures visible from the inside of the skull) suture method. This method is used in the same manner as the ectocranial suture method. First the sutures are scored as open, commenced or terminated. Then, these scores are compared to table 14 below to get the corresponding age.

(Table 14)

Suture	Commencement	Terminated
Sagittal	22	35
Coronal	24	41
Lambdoidal	26	47
Masto-occipto	30	81
Spheno-temporal	30	67

*From Skelton (Fall 1999: 13)

Using this method, the sagittal suture was scored as terminated which gave a corresponding age of 35+. The coronal, lambdoidal and masto-occipito sutures were all scored as commenced which gave the ages of 24-41, 26-47, and 30-81 respectively. Overall, this gave UMFC12 a narrow age range of ***35-41***, and a wide range of ***35-81*** years of age at the time of death.

The next suture closure method of age determination that I will look at is the Baker (From Skelton 1999) method. This method, again looked at both endocranial and ectocranial sutures, and the sutures are scored as either open, commenced, or terminated. Table 15 shows the corresponding ages for these scores.

(Table 15)

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

*From Skelton (Fall 1999: 14)

Using this method, I scored the sagittal endocranial suture as terminated. This gives UMFC 12 an age of at least 25 years. The sagittal ectocranial suture was scored as commenced which gives the individual an age at death estimation of 19-83. The lambdoidal endocranial and ectocranial sutures were both scored as commenced which gives the corresponding age ranges of 19-74 and 24-84. Finally, the coronal endocranial and ectocranial sutures were both scored as commenced which gave corresponding ages of 22-79 and 24-89 respectively.

Overall, an analysis of the cranial sutures using the Baker method gave a narrow age range of ***25-74***, and a wide age at death estimation of ***19-89***. As with the Todd and Lyon method this method should always be used in conjunction with other estimators of age.

The last method of age from suture closure that I will look at is the suture site method as presented in White and Folkens (2000). For this method, instead of looking at the cranial sutures as a whole, the researchers proposed that ten "cranial suture segments each be given a numerical score. The score of 0, or open is given when there is no evidence of any ectocranial closure. A score of 1 is given to suture sites with minimal closure. A score of 2 is given to sites with significant closure, and a score of 3 is given to a completely obliterated suture" (White and Folkens 2000: 347). Obviously this method is somewhat subjective in practice. The authors give no clear definition of the difference between "minimal" and "significant" closure, these judgments are left up to the researcher's discretion. Nonetheless, White and Folkens suggest that the following suture sites (shown in table 16), developed by Walker, which are presented by Buikstra and Ubelaker (1994) be used when attempting this method.

(Table 16)

Site Name	Description
1) Midlambdoidal	Midpoint of left lambdoidal suture
2) Lambda	Intersection of sagittal and lambdoidal
3) Obelion	At obelion
4) Anterior sagittal	One-third the distance from the bregma to lambda
5) Bregma	At bregma
6) Midcoronal	Midpoint of left coronal suture
7) Pterion	Usually where parietosphenoid suture meets the frontal
8) Sphenofrontal	midpoint of left Sphenofrontal suture
9) Inferior spenofrontal	Intersection between left Sphenotemporal suture and line between articular tubercles of the temperomandibular joint
10) Superior Sphenotemporal	On left sphenotemporal suture 2 cm below junction with parietal

*From White and Folkens (2000: 348, figure 17.4).

Once the suture points discussed above are examined and given a score from 0-3, you now have to determine the corresponding age using the procedure described by Meindl and Lovejoy (1985). For UMFC 12, sutures 1-10 were scored as follows. Sutures 1-4 all scored as 2, sutures 5 and 6 scored as 1, sutures 8 and 9 scored as 2, and suture 10 scored as 1. Tables 17 and 18 below show what the corresponding age is for the composite score of sutures 1-7, and 6-10. To determine composite scores you simply add up the scores given to suture sites 1-7, and then add up the scores given to suture sites 6-10.

(Table 17)

Composite Score	Mean Age	Standard Deviation
0	--	--
1-2	30.5	9.6
3-6	34.7	7.8
7-11	39.4	9.1
12-15	45.2	12.6
16-18	48.8	10.5
19-20	51.5	12.6
21	--	--

* (add scores 1-7)

(Table 18)

Composite Score	Mean Age	Standard Deviation
0	--	--
1	32.0	8.3
2	36.2	6.2
3-5	41.1	10.0
6	43.4	10.7
7-8	45.5	8.9
9-10	51.9	12.5
11-14	56.2	8.5
15	--	--

* (add scores 6-10)
**From White and Folken (2000: 348, Fig. 17.4), After Meindl and Love (1985)

For UMFC 12 the composite score for sutures 1-7 was 12 (2+2+2+2+1+1+2). Using table 17 above, this gives us a corresponding age of ***45.2 ± 12.6*** years. Looking at sutures 6-10, the composite score was 8 (1+2+2+2+1). Using table 18 this gave a corresponding age of 45.5 ± 8.9 years. Therefore, the wide range garnered from the suture site method is ***32.6 - 57.8*** years old, and the narrow range is ***36.6 – 54.4*** years old.

Overall, I was able to get a fairly good indicator of age from cranial suture analysis. These scores will be summarized in the conclusions on age section of this paper.

Age From Medial Clavicle Epiphysis

The next method of age determination that I used in the analysis of UMFC 12 was medial clavicle epiphysis closure. This method was developed by Mckern and Stewart and presented in Bass (1995) on page 132. According to the researchers, "from the ages of 25-30 the majority of cases are undergoing terminal union. The last site of union is located in the form of a fissure, along the inferior border. With the obliteration of these fissures (at age 31) the epiphysis is completely united (Bass 1995: 132). In examining the right and left clavicles of UMFC 12, it was determined that both were completely fused. The fissures along the inferior borders of the bones were completely obliterated. Therefore, using the description above, it was determined that UMFC was 31+ years of age.

This method of aging has also been looked at by Suchey and presented in Bass (1995) on page 135. According to Suchey, in a sample of 130 left and 124 right clavicles between the ages of 31-40, 100% were completely fused. Again, this tells us that the individual making up UMFC 12 was most likely at least 31 years of age at the time of death.

Age From Sternal Rib Ends

The determination of age at death from the sternal rib ends has been studied extensively by forensic anthropologists. The method that I will use was developed by Iscan (1984a, 1984b) and is based on the degenerative changes of the 4^{th} ribs. To apply this method you must examine the sternal end of the 4^{th} rib of the individual under study and compare it to the descriptions and pictures put forth by Iscan. In doing this you can assign the rib to 1, of a set of 8 phases based on the descriptions. Each phase has a corresponding age that was determined by Iscan in his research. Iscan got his data for this study from autopsied individuals of known ages, and "the distribution of specimens into phases was based on changes noted in form, shape, texture and overall quality of the sternal rib"(Bass 1995: 140). Using the left 4^{th} rib of UMFC 12, it was determined that the individual fell well into phase 5 based on the descriptions and pictures presented by Iscan (1984a). This gives us an age at death estimation of ***34.4 - 42.3*** years of age. The description associated with phase 5 is as follows; "there is little change in pit depth, but the shape in this phase is predominantly a moderately wide U. Walls show further thinning, and the edges are becoming sharp. Irregularity is increasing in the rim. The scalloped pattern is gone completely and has been replaced with irregular bony projections. The condition of the bone is fairly good. There are however, some signs of deterioration, with evidence of porosity and loss of density" (Bass 1995: 142, after Iscan 1984a: Table 2).

The left 4^{th} rib of UMFC 12 showed the following characteristics: the shape of the rib end is a moderately wide U shape. The walls are beginning to thin and appear to be sharpening. There are some bony projections beginning to appear, and there are some signs of deterioration and porosity at the rim, however, the condition of the bone is still fairly good.

If you look at Iscan's complete list of phases and their descriptions you will notice that some of these characteristics are also found in ribs classified as phase 4 (moderate wide U shape, thinner walls, beginnings of an irregular rim). However, because deterioration and porosity are getting started and the edges are getting sharp, the sternal end of the left 4^{th} rib of UMFC 12 fits much better into Iscan's phase 5. Moving in the other direction, UMFC 12 does not at all fit into phase 6. There are no "long" bony projections (although they are beginning to form), and the porosity and deterioration that is present is barely noticeable.

To conclude, using the sternal rib end age method, it was determined that UMFC 12 was most likely between the ages of ***34.4 – 42.3*** years of age at the time of death.

Age From Long Bone Epiphysis Closure

This is a vague form of age at death estimation, especially when it is used on adult specimens. For the most part, epiphyses of the long bones of adults will be completely fused. Therefore, it most cases we can only say that the individual under study was at least "X" years of age. Let me demonstrate using UMFC 12 as an example.

The first long bones that I examined were the left and right humerii. Mckern and Stewart (1957) say that the medial epicondyle is "completely united by age 19" (Bass 1995: 154). The medial epicondyle of UMFC 12 is completely united, therefore we can conclude that this individual was at least 19 years of age at the time of death.

The next set of long bones I looked at were the right and left radii. Again, using Mckern and Stewart (1957) as presented by Bass (1995) I determined that UMFC 12 was at least 19 years old based on the proximal epiphysis, and at least 17 years old based on the distal epiphysis (Bass 1995: 168).

Moving along, the left and right tibias were the next bones that I examined. Johnson (1962) did research on age determination from the tibia based on "skeletal data from Indian Knoll" (Bass 1995: 246). According to Johnston, the distal epiphysis of the tibia comes to complete union by 20 in males, and the proximal epiphysis comes to complete union by 23 in males (Bass 1995: 247). Based on the fact that UMFC 12 is a male, and that both the proximal and distal epiphysis's are completely fused, it was determined that this individual was at least 23 years of age at the time of death.

Finally the last long bone that I examined was the left ulna. Once again, Johnston's (1962) data was used in the analysis. He says that "the proximal end usually unites with the shaft at age 19 in males" (Bass 1995: 174), while the distal end unites [fuses] with the shaft "in males from 17-18" (Bass 1995: 174). UMFC 12's proximal and distal epiphysis were both fused telling us that this individual was most likely at least 19+ years of age at the time of death.

To conclude this section, it is safe to say that age from long bone epiphysis closure in adults is only marginally helpful at best. These methods are best used as an indicator of age, especially early on in the examination. Instead, age from long bone growth and epiphysis closure is a much better method for determining age in sub-adults and children. In the case of UMFC 12, epiphysis closure was helpful in that it was another indicator that the individual was indeed an adult that was at least 23 years of age at the time of death (based on the fusion of the proximal epiphysis of the tibia).

Age From the Development of Osteophytosis

The last method of age determination that I used with UMFC 12 was the development of Osteophytosis on the vertebral column. This method is "accomplished by assessing the development of osteoarthritic lipping at the edges of vertebral disks" (Burns 1999: 64). As with other methods of aging from degenerative changes, Burns has categorized the degenerative changes that occur through life in the vertebral column into stages that have a corresponding age range. The age of the individual is then determined by comparing the changes seen in the skeletal material being analyzed with the pictures and descriptions of each stage.

UMFC 12 fit Burns's stage 4 (Older Adult), which has a corresponding age of 30+. The description of this stage is as follows: "Osteoarthritis is obvious and the vertebral body is beginning to degenerate. Note the osteophytes of the vertebral edges and the porous nature of the bone" (Burns 1999: 65). Osteoarthritis was obvious on the 3rd, 4th, and 5th lumbar vertebrae, with osteophytes present at the edges. Also, the vertebral bodies were beginning to degenerate. So, to conclude, this individual is most likely 30+, based on the development of Osteophytosis.

Conclusions on Age Determination

Aging an individual can be a very complicated task. As you have seen there are quite a number of methods that can be used to accomplish this goal with differing levels of reliability. Because of this, it is important that researchers use a multifactorial approach to age determination whenever possible. In some cases, especially when there are a limited number of bone elements available for analysis, a multifactorial approach may not be possible. However, when there is a complete or nearly complete skeleton available for examination "it has long been known that more than one area, bone, or criteria should be used [in age at death estimations]" (Bass 1995: 19). As I have shown, UMFC 12 was a fairly complete specimen, which made it possible to use a multifactorial approach. To do this, I simply used the age ranges that were determined using the individual methods described above to come up with an overall wide and narrow age at death estimation. First, it can safely be stated that this individual was an adult, as confirmed by epiphysis closure of the long bones and the development of osteophytosis on the vertebral column. Next, let us take a look at the age ranges that were derived from the examination of tooth wear (dental attrition), clavicle epiphysis closure, sternal rib ends, and cranial suture closure. Using Brothwell's dental attrition method gave an age range of 25-55 years old. Using Tromley's dental attrition method gave a wide range of 26 – 47, and a narrow range of 35-37. For the medial clavicle epiphysis, both the Mckern and Stewart, and Suchey methods gave an age of 31+. Next, using Iscan's sternal rib end method gave an age range of 34.4 – 42.3 years. Last but not least, using the Todd and Lyon ectocranial method, gave a wide range of 20 – 50, and a narrow range of 26 – 31, while the endocranial method gave a wide range of 35 – 81, and a narrow range of 35 – 41. The Baker method of age at death determination from cranial suture closure gave us a wide range of 19 – 89, and a narrow age range of 25 – 74. Finally, the suture site method as presented by White and Folkens gave us an age range of 32.6 – 57.8, and a narrow range of 36.6 – 54.4. From looking at these age ranges, one could conceivably make the statement that this individual was around 37 years of age at the time of death. Why 37? First, we can safely throw out any possible age ranges lower than 31 based the fact that this individual showed signs of Osteophytosis development, and from the examination of the sternal rib ends. Also, the majority of the age ranges determined fall into the mid-thirties to the mid-forties. In any case, 31+ gives us a good place to start. Next, looking at the remaining viable age ranges, the highest, lower end of the age range possible is 36.6 (from the suture site method), while the lowest, higher end of the age range possible is 37 (from the narrow Tromly range). This would indicate an individual around 37 years of age at the time of death. However, this estimate is unacceptably narrow. It simply is not possible, even though the numbers may show it, to definitively narrow down someone's age to one year with any amount of accuracy. It would be irresponsible for a forensic anthropologist to include such an estimate in a report. Instead, I would be much more comfortable giving this individual a narrow age range of ***32.6 – 42.3*** years, and a wide range of ***20 – 74*** years of age at the time of death. I chose these numbers based on the evidence available. It seems most likely to me that the individual was in his mid-thirties to early-forties. However, some of the ranges that were determined were quite variable, so narrowing it down any further than 10 or so years did not seem practical to me. Therefore, I used the low age given by the suture site method and the high age given by the sternal rib end to come up with my narrow range. My wide range was determined by using the low age from the Todd and Lyon ectocranial suture method, and the high age from the narrow range from the Baker method of cranial suture closure. Overall, I do not think this individual was as young as 20 nor as old as 74, but the wide range is given because although highly unlikely, this person could technically fall into this range of age variability. However, more than likely this person was in their mid-thirties to early-forties when they died based on the evidence presented by the skeleton. I would feel much more confident in this conclusion, and could probably find a narrower age range, if the pubic symphysis and auricular surface of the coxal bones were available for analysis. Instead, suffice it to say that I am confident that this person was most likely between ***32.6*** and ***42.3*** years of age at the time of death.

Stature and Weight

Stature and weight are two very important pieces of information that forensic anthropologists are sometimes able to determine from skeletal material. First, you must determine the sex and preferably the racial affinity of the individual under study. For UMFC 12 it has been determined that this individual was most likely a White male.

After the race and sex of the individual has been determined, estimating the stature of an individual from skeletal remains is actually a fairly simple task, thanks to researchers like Trotter and Glesser (1952, 1958) who have developed the "most reliable" (Bass 1995: 26) method of stature estimation. With the use of regression equations, Trotter and Glesser developed "stature estimation tables for Whites and Blacks [those of European and African ancestry]" (Bass 1995: 26). To use this method, you simply measure the maximum length of long bones, and plug them into the regression formula, or table developed by Trotter and Glesser, and presented in Bass (1995), for the sex and "racial" affiliation the specimen comes from. For example, UMFC 12's left tibia measures 360 mm in total length. Looking at Trotter and Glesser's table for males of European ancestry tells us that a 360 mm long tibia corresponds with a stature of approximately 169 cm, or 66 inches (5'6"). Going a step further, the regression formula for this bone is: 2.42(tibia length in cm) + 81.93 = X ± 4.0. If we plug in the tibia length for UMFC 12 we get 2.42(36) + 81.93 = ***169.1 ± 4.0 cm***. All the long bones of the body were used by Trotter and Glesser in developing their tables.

Let us now examine the stature estimates that were determined from UMFC 12's long bones. Since I have already determined that UMFC 12 is most likely of European ancestry and is male, I will use the corresponding tables. The first bone I looked at was the left humerus, which measured 320 mm and corresponds with a height of 169 cm (5'6 ½"). Next, I looked at the right radius which measured 240 mm. This gives a corresponding stature of 170 cm (5' 6 7/8"). The left ulna of the individual measured 258 mm and, the corresponding stature estimation of this measurement is 170 cm (5'6 7/8"). Finally, the left femur of UMFC 12 measured 442 mm which gives us a corresponding height of 166 cm (5' 5 3/8"). Overall, it is believed that the individual making up UMFC 12 was between 166 – 170 cm tall at the time of death (five foot five and three/eighths inches – five foot six and seven/eighths inches). As you can see this is a fairly narrow range, and therefore it's reliability can certainly be called into question. One way to extend this range is to use the actual regression formulas put forth by Trotter and Glesser. Using these (and their corresponding standard deviations) the possible range of height for UMFC 12 is 164 cm (5' 4 5/8") to 177 cm (5' 9 5/8"). This is a more believable height range. I would be much more comfortable telling law enforcement authorities that the individual in question was between 5' 4" and 5' 9", than I would in telling them he was between 5'5" and 5'6". Nonetheless, for the purpose of this paper we can say the narrow height range for this individual was approximately ***5'5" – 5'6"***, and the wide range was **5'4" – 5'9"**.

Now that the possible height of the individual has been determined, it is now time to find a corresponding weight at death for UMFC 12. An individual's weight for a given height can be quite variable. For example, some individuals who are 6 feet tall may weigh 165 lbs. while another 6 foot individual may weigh 240 lbs or more. Therefore it is important to attempt to find some indicators of possible weight in the skeletal material under study. These may be in the form of large muscle attachments, or very smooth gracile bones. Unfortunately this is the best we can do from the examination of skeletal material. If an individual was six feet tall but was found with size 44 waist pants we can then infer that he was a more robust or even obese individual. However, lacking cultural artifacts, we can only find what markers are available on the skeleton. Once this determination has been made, finding a possible weight at death estimation is very easy. One simply compares the determined height with “the standard height-weight chart compiled by the Metropolitan Life Insurance Company” (Skelton 1999: 93). One thing to keep in mind in the case of UMFC 12 is that for age 35-40 years you should always “add 1% per year over 35” (Skelton 1999: 93).

So, let us now figure out the weight of UMFC 12. First and foremost, we need to figure out an average or mean height to start with. As of right now we have a height range of between 5’4” and 5’9”. If we gave a corresponding weight range for this height range it would be 104 lbs- 162 lbs, this is without adding weight for advanced age. As you can see this is a fairly large weight range. Instead, we should try to figure out a mean height of some kind. In this case I will use the narrow height of approximately 5’ 6”. This is the approximate median height of the individual, and it falls well within the narrow range given above. Next we need to figure out an approximate median age. As I stated above, this individual was most likely between 32.6-42.3 years of age. From this we can get an approximate median age of 37 years. That means we have to add 2% of the total weight to the final weight estimation. So, with a height of 5’6” and assuming that the individual had a medium build, this individual would have an approximate weight of 137 ±21 lbs. Adding 2% to the total for age would give us a weight of 139.5 ± 21.4 lbs.

Overall it can be said this individual was approximately 5’6” inched tall with a weight of 139.5 ± 21.4 lbs. Having stated this, one should keep in mind that the individual could be as short as 5’4”, or as tall as 5’ 9”, and could weigh anywhere from 104 lbs- 162lbs.

Pathology and Trauma

The pathology and trauma exhibited on human skeletal remains can be of great importance to researchers and law enforcement authorities. First and foremost, it can be very helpful in identification. Pathologies and traumas that appear on the human skeleton often required treatment in life. Therefore, a positive identification of skeletal material can often be made with the help of medical records. Also, the pathology and trauma present on skeletal material can sometimes show a cause and manner of death. This is, obviously, very important to investigators. Finally, pathology and trauma can often give you insight into who the person was, what they did for a living, and what type of life they led. For example, repetitive injuries may give researchers insight into a person's line of work.

Basically, pathology is a condition usually caused by a disease or infection, while trauma is a condition be caused by accidents, confrontation, etc. and are characterized by phenomena like fractures, or cut marks. Pathological and traumatic conditions on the bone can be broken down into three very important categories, premortem, perimortem and postmortem. Premortem trauma can be characterized as trauma that occurred prior to death. This type of trauma can be recognized "due to the fact that there will be some healing of the bone, giving the margins of the defect a smoothed appearance" (Skelton 1999: 46). Perimortem trauma can be characterized as trauma that occurs around the time of death, and "therefore might constitute evidence about the cause, manner, or circumstance of death" (Skelton 1999: 46). This type of trauma is recognized by "the fact that the margins of the defect are the same color and weathered to the same degree as the surrounding bone, and there is no smoothing of the margins due to healing" (Skelton

1999: 46). Finally, postmortem trauma can be characterized as trauma that occurred on the bones after death. This type of trauma can be recognized "by the fact that the margins of the defect are not weathered to the same extent as the surrounding bone, and there is often a difference in color due to exposing the unweathered interior of the bone" (Skelton 1999: 46). Determining whether or not a trauma is pre-, peri-, or post mortem is very important to law enforcement officials. One thing to keep in mind is that forensic anthropologists are not qualified to diagnose conclusively, the cause of a pathology or trauma exhibited on the bone. For example, if we get a skull with an obvious entrance and exit trauma caused by the passing of a bullet, we as forensic anthropologists cannot say that the cause of those traumas is a gunshot. This determination falls within the realm of the coroner, medical examiner, or firearms examiner. Instead, our job is to be descriptive, while leaving the diagnosis to those qualified to make them. Forensic anthropologists would most likely call those entrance and exit wounds "circular defects" in a forensic report.

Now that I have talked about the difference between pathology and pre-, peri- and post-mortem trauma, let us now take a look at the trauma exhibited on UMFC 12.

Trauma

Overall, this individual lacked any visible premortem or perimortem trauma. Nonetheless, there were an excessive number of traumatic injuries to the bones that I would classify as postmortem based on the criteria I discussed above. There are a number of taphonomic processes that the bones will go through once they are deposited into the ground. These processes will often alter bone, or leave their mark on them in some way.

It is the forensic anthropologist's job to determine whether the alterations seen on the skeleton upon examination were harmlessly caused by postmortem taphonomic factors, or by pre-, or perimortem factors. The taphonomic factors that can affect bones once deposited after death include "animals, gravity, water and fluvial processes" (Haglund and Sorg 1997: 77). Animals can be particularly destructive on remains, especially if they are not buried. Animal related processes "include trampling, entrance fall, gnawing, and digestion" (Haglund and Sorg 1997: 77). However, other processes can be very destructive as well. These processes, which include " rock fall, water transport, sandblasting weathering, burial, diagenic movement, volcanic shockwave, acid attack by roots, cryoturbation, release and breakup by bottom-fast ice, and mineralization in ground water" (Haglund and Sorg 1997: 77), are most likely the cause of the postmortem trauma seen on the remains of the individual making up UMFC 12. To start the discussion of the trauma exhibited on UMFC 12 I am going to look at the skull. As you will see, a lot of this trauma was covered in the inventory section of this report. However, I feel that it is important to reexamine the remains to make it perfectly clear what would be considered postmortem and why.

The first piece of trauma that was noticed consisted of an 18.7 mm deep piece of the right mastoid process that was missing. This trauma was deemed postmortem based mainly on the coloration, but also on the jagged edges. This showed that the piece had been broken off sometime after death. On the occipital bone, there was a small piece of the bone missing just inferior to the right mastoid process. This piece was oval shaped and measures 31.2 mm by 37.5 mm, and was also judged postmortem based on the coloration and the sharpness of the broken edges. Another noticeable postmortem trauma on the skull was the shifting of the occipital bone in the region of the basilar suture. A force of some kind, possible soil pressure, caused the occipital bone to shift approximately 7mm to the right at its conjunction with the basilar suture. Again, based on the coloration of the bone exposed by the shift, it is believed that this trauma was postmortem. Near the confluence of the frontal, right parietal and sphenoid bone there was a crack that measures 58.4 mm long and extends well into the right parietal bone superiorly. This trauma was also judged to be postmortem based on the sharpness of the edges and the coloration of the exposed bone. The right temporal bone has been separated from the rest of the skull and was probably popped off postmortem from a taphonomic process such as soil pressure. On the right superior portion of the occipital bone there was some heavy deterioration or weathering that occurred postmortem based on the coloring, and sharpness of the worn edges. Staying with the right side of the skull, there were two small scrapes across the right parietal bone measuring 21.5 mm and 18.4 mm respectively. These scrapes were horizontal with the larger one superior, and appear to be postmortem based on coloration. Finally, there was a small amount of postmortem wear, or deterioration on the left side of the upper face encompassing the surface of the outer margin of the eye socket, extending up into the frontal bone. This wear was classified as postmortem based on the coloration of the exposed bone, and the lack of healing.

On the postcranial skeleton, the next area of trauma that I will discuss was on the right humerus. This bone also had a significant pathology that I will discuss in the next section. The trauma to this bone consisted of a missing section of bone on the proximal end that started in the head and extended down through the neck and into the shaft. This piece measures 52.5 mm by 34.1 mm and was considered to be postmortem based on the coloration of the exposed bone and the jagged edges. This trauma does not have any clear gnaw or bite marks so it was most likely caused by one of the physical taphonomic processes discusses above (running water, exposure to wind, poor handling, acidic soil etc.). There is a similar area of trauma on the left humerus as well. This trauma was also located on the proximal end and encompasses approximately ½ of the head. It measured 41.6 mm by 46.9 mm. This trauma was considered to be postmortem based on coloration and the sharpness of the edges, and once again there appeared to be no sign of animal activity leaving other taphonomic processes as the most likely culprit. The two radii of the individual also had a small amount of trauma confined to the head. This trauma can best be characterized as deterioration and was most likely caused by acidic soil, or what is sometimes called coffin wear, which is the rubbing of the bones against the wood of a coffin or the soil. Again, coloration and sharp edges showed that this trauma was most likely postmortem. The trauma on the right ulna consisted of the majority of the olecranon, and the semilunar notch being missing. Again this would be considered postmortem based on coloration and sharp edges.

Moving away from the arms, the next trauma that I will discus was on the sternum. The whole manubrium of the bone was missing, but I classified it as postmortem based on the jagged sharp edges at the point of the break and the difference in coloration.

The vertebrae of the individual making up UMFC 12 also had a large amount of postmortem trauma present. I will quickly list the trauma present, all of which was classified as postmortem based on the coloration of the exposed bone, and the jagged characteristics of the broken edges: lumbar 1 was missing the spineous process, the right transverse process, and the right inferior articular process, lumbar 2 was missing the right transverse process, and both inferior articular processes, lumbar 3 was missing the majority of the right transverse process, and the spineous process, lumbar 4 was missing the spineous process, lumbar 5 was missing the left inferior articular surface, and the left transverse process.

Moving on to the thoracic vertebrae, 7 of the first 9 thoracic vertebrae were available for analysis. However, due to heavy deterioration their exact location on the vertebral column was unable to be determined. Of the seven, five were missing the right and left transverse process while 3 were missing all the superior and inferior articular surfaces. Thoracic vertebrae 10 lacked the right and left transverse processes, the spineous process, and all articular surfaces. Finally, thoracic 11 lacked both transverse processes, the spineous process, and the right inferior articular surfaces.

The sacrum of UMFC 12 also showed a large amount of postmortem trauma. The body of the bone was missing, having been broken off just inferior to the promontory, and just superior to the first sacral foramen. The portion of the bone that was available for analysis was broken into two pieces at the right ala. Again this trauma appears to be postmortem based on the coloration and the jagged edges of the broken bone.

The next set of bones that I will discuss, are the right and left scapulas. Both these bones exhibited intense postmortem trauma. The right scapula was missing the majority of the spine, the medial border, the subscapular fossa, infraspineous fossa, and the inferior angle. The left scapula was missing the exact same features as the right scapula, except that there was a small portion of the inferior angle present that was separated from the rest of the bone. Again, this trauma appeared to be clearly postmortem, based on the coloration of the bone and the sharpness of the breaks.

Leaving the upper body, let us now take a look at the lower half of UMFC 12. The first bones that I examined were the coxals. Both these bones showed severe postmortem trauma. I'll start with the left. The portions missing from this bone (broken off) included: all portions inferior to the base of the greater sciatic notch, including the lesser sciatic notch, the ischium, and the lower margins of the obturator foramen. Also, just superior to the greater sciatic notch there was a section of bone missing that included the posterior inferior iliac spine. A portion of the pubis was present. but was broken off at the acetabulum and ventral margin. The right coxal bone was broken into two pieces. The first piece included the greater sciatic notch, the posterior portion of the acetabulum, and a portion of the main body of the ischium (not including the ischial tuberosity). The second piece included the ilium, the crest of the ilium, the iliac fossa, the anterior superior iliac spine, and the anterior inferior iliac spine. These two pieces were broken apart at approximately the anterior superior iliac spine. All trauma on the coxal bones appeared to be postmortem in nature. There are sharp edges along all the breaks, and the coloration of the exposed bone was much lighter than that of the exterior bone. Again this trauma appeared to have been caused by natural taphonomic processes, or careless human handling.

Continuing on, the next bones that I will discuss are the femurs. The right femur exhibited the following postmortem trauma: the greater trochanter and a portion of the lesser trochanter were missing (the missing section measures 47.7 mm by 49.2 mm). Also, a large portion of the lateral epicondyles was missing. The left femur had similar trauma. A large portion, measuring 66.4 mm by 37 mm, of the greater trochanter and lesser trochanter was missing. Also, a section of the posterior portion of the lateral epicondyles was missing. Once, again, based on coloration and the sharpness of the broken edges, this trauma was deemed postmortem.

The tibias were the next bones examined for trauma. Once again these bones exhibited what appeared to be postmortem trauma based on the light coloration of the exposed bone and the sharpness of the edges. On the right tibia, the majority of the lateral condyle was missing, as well as the fibular articular surface, and a vast majority of the tibial tuberosity. This deterioration extended down the popliteal line to its conjunction with the anterior crest. The left tibia showed a small amount of deterioration just inferior to the lateral condyle, extending across the posterior margin of the lateral and medial condyles, and the intercondylar eminence.

Moving onto the feet, all the trauma apparent on the tarsal and metatarsal bones once again appeared to be postmortem. There was no sign of any type of sharp, blunt, or other trauma prior to death. Both the left and right calcaneous showed a small amount of what is best termed as deterioration on the lateral sides. This trauma was most likely due to coffin wear of some kind. The right and left talus, right and left navicular, and the right and left medial cuneiforms all showed small amounts of deterioration or wear over the majority of the bone surface. Again, this is most likely due to the coffin wear phenomenon. This trauma was determined to be postmortem based on the coloration and lack of healing. The left and right cuboids showed some severe trauma deemed postmortem . Both bones were missing the majority of the body, and the smooth non-facet surface. Also, the left cuboid was missing most of the pointed articular facet.

The metatarsal bones of this individual also showed a large amount of postmortem trauma. The right first metatarsal displayed the shearing away of the lateral portion of the bone. This shearing was most likely due to exposure to some kind of abrasive surface postmortem. The left first metatarsal was missing the plantar portion of the bone. This was also deemed postmortem based on the coloration and sharpness of the edges. The left second, third, and fourth metatarsal all were missing the distal plantar portions of the bone. This trauma was deemed postmortem based on the coloration of the bone and the sharpness of the broken bone. This deterioration may again be caused by exposure to an abrasive surface.

Two of the phalanges of the feet also showed some postmortem trauma. The right third and fourth metatarsal bones were missing the proximal ends. This trauma was deemed postmortem based on the light coloration of the exposed bone and the sharpness of the broken edges.

As I noted above, this individual did not have any true pre, or perimortem trauma present on the skeleton. Instead, this individual had a large amount of postmortem trauma caused by normal taphonomic processes such as weathering and exposure to abrasive substances. However, there were some premortem pathologies present on the skeleton that I will discuss in the next section.

Pathology

Pathology can show up on the skeleton in many shapes and sizes. For example, there are infectious diseases which can "be passed from individual to individual, sometimes by way of an intermediate host" (Skelton 1999: 41). Some of these diseases may include Osteomyelitis and Periostitis which are infections of the bone, chronic ear infection, meningitis, and syphilis. All of these diseases (and many others) can leave their mark on the skeleton. Other diseases that show themselves on the skeleton include degenerative joint diseases such as arthritis, dental pathologies such as caries or cavities, and cancers. UMFC 12 shows two types of very distinct pathologies, dental pathologies, and a possible tumor or cyst.

The two types of dental pathologies that were present on UMFC 12 were caries and tooth loss. Caries "are caused by bacteria living in your mouth that secrete acids to digest sugar and other foods (Skelton 1999: 43). This pathology is characterized by "pits" on the teeth and is often readily visible to the naked eye. Tooth loss can be seen "when the alveolar bone forming its socket is resorbed by the body leaving a characteristic smooth appearance where the tooth-socket used to be" (Skelton 1999: 43). On UMFC 12, the following teeth showed evidence of carries: the 2nd upper left premolar, and the third upper right molar. Both teeth showed heavy pitting and discoloration most likely due to dental caries. Tooth loss is apparent on both upper right premolars, the upper right canine, the lower right second molar, and the lower left second molar. This tooth loss was considered premortem based on the resorbtion of the tooth sockets of those teeth. Now let us move on to the cyst or tumor apparent in UMFC 12.

As a general rule, there are two types of tumors or cysts that can manifest themselves on the human skeleton, benign and malignant. Tumors that "consist of well-differentiated (mature) tissue and remain localized" (Ortner and Putschar 1981: 365) are considered benign. Tumors or cysts that "consist of poorly differentiated (immature) tissue, and continue to grow unchecked and can spread to other parts of the body through blood vessels and/or lymphatics" (Ortner and Putschar 1981: 365) are considered malignant.

In the case of UMFC 12, there are two questions that needed to be answered regarding the pathology present on the proximal right humerus. First, I had to determine whether or not the pathology present had been caused by a traumatic injury such as a fracture, or by a pathological condition such as a tumor or cyst. Second, I needed to determine whether it was a benign tumor of some sort, and to diagnose, to the best of my ability, what kind of tumor or cyst it was.

Fractures can be defined as "the result of a traumatic event that leads to a complete or partial break of the bone" (Roberts and Manchester 1997: 67). Healed fractures can often be seen in the skeleton, but sometimes remodeling of the bone can lead to the "eventual restoration of the normal architecture of the bone to its original appearance" (Roberts and Manchester 1997: 72). However, radiography "aids considerably in the interpretation of fractures, particularly to asses the mechanism behind the injury (type of fracture), and the state of healing of the fractured bone" (Roberts and Manchester 1997: 72). Luckily, radiographs of the right proximal humerus were taken when the first examination of these remains was conducted by Dr. Smith. The radiographs do not show any sign of fracture whatsoever. Keeping in mind that it is possible that bone remodeling may have obliterated any evidence of fracture, it is important to note that there was still a large pathology present at the site. If the condition present on the humerus was indeed a fracture, I would expect to see some sign of it either by examination of the bone or the radiographs considering there is still such as large pathology present.

That leaves us with another explanation for this pathology, a tumor or cyst. While combing through literature regarding malignant and benign tumors or cysts I found two possible causes for the pathology. The first possibility is called a "unicameral bone cyst" (Ortner and Putschar 1981: 366). This is a benign cyst that is "most common in long bones and starts in the metaphysis in close proximity to the growth plate" (Ortner and Putschar 1981: 366-367). Ortner and Putschar note that one of the most frequent locations for this type of cysts is indeed the proximal humerus. unicameral bone cysts consist of "a round or oval shaped fluid-filled cavity of several centimeters in diameter that is lined by a thin membrane of poorly vascularized osteogenic mesenchyme" (Ortner and Putschar 1981: 366). This type of cyst certainly seems like a possibility for UMFC 12, however, the pathology did not seem to be a "cavity", but rather a growth that was completely filled in with bone. Nonetheless, I would still consider a diagnosis of unicameral bone cyst a possibility. .

The next type of tumor that struck me as a possibility in the case of UMFC 12 was an Osteochondroma of the humerus. This is a type of benign tumor usually caused by "strictly developmental aberrations due to faulty ossification of the growth plate" (Roberts and Manchester 1997: 187). These tumors "are one of the more common bone tumors" (Ortner and Putschar 1981: 370), and are commonly found on the proximal humerus. Unlike unicameral bone cysts, the insides of Osteochondromas are often "heavily calcified and sometimes ossified" (Ortner and Putschar 1981: 370). These tumors are relatively non-intrusive, with often the "only symptom is the inconvenience of a localized swelling on a limb" (Roberts and Manchester 1997: 187-188). I believe that there is a strong possibility that the pathology seen on UMFC 12 was indeed an osteochondroma. It fits the description very well and looks uncannily similar to the example pictures given by Roberts and Manchester (1997).

The reason that I felt that these two types of benign tumors/cyst were the most likely suspects for the pathology seen on UMFC 12 was the location of the pathology and the form it took. Obviously I am not a medical doctor and I am not qualified to make a conclusive diagnosis regarding the pathology affecting this case. However, from a purely descriptive sense, the two possibilities above fit the criteria very well. Both occur very frequently near the growth plates of long bones, especially the humerus, and both take the form of smooth bony outgrowths that do not affect the epiphysis of the bone. Also, neither cause major destruction or deterioration of the outer surface of the bone. If I had to choose, I would say that the pathology is most likely an osteochondroma of the proximal humerus. The pathology exhibited on UMFC 12 fit the description for this condition very well. However, with my meager medical knowledge, I could not make that determination with any amount of absolute certainty.

Conclusions Regarding UMFC 12

This was a very interesting case to work on. Although I certainly would not consider this a forensic case based on the fact that the individual was recovered nearly twenty years ago, and has most likely been dead since at least 1900, it is still a very useful part of the University of Montana-Missoula's Physical Anthropology Laboratory.

Overall, it could be said that this case represents a male of European ancestry between the ages of 32.3-42.6 years old at the time of the death. The individual was probably around 5'6" tall and weighed 139.5 ± 21.4 lbs. and most likely was afflicted with some type of benign growth of the proximal right humerus in life. Again, based on the background information available for this case, this individual probably died in excess of 100 years ago.

Although this case is very old, it still can be very helpful to students using our laboratory for Forensic Anthropology training. It is diagnostically a middle-aged male of European ancestry around 5'6" with some pathologies. However, this skeleton does have enough variability that it is still an excellent teaching specimen. It shows some of the problems that forensic anthropologists come up against when performing and analysis. An example of this would be the small stature of UMFC 12 and how this makes sex determination difficult, especially when using the length of the long bones. This type of variability is what forensic anthropologists encounter everyday. Learning to understand this variability when analyzing skeletal remains should be a large part of any forensic anthropologists training.

Appendix A

Cranial Measurements

1) Maximum Length (g-op)	193	13) Nasal Height (n-ns)		53
2) Maximum Breadth (eu-eu)	146	14) Nasal Breadth (al-al)		21.1
3) Bizybomatic Breadth (zy-zy)	136	15) Orbital Breadth (d-ec)	Left	38.6
			Right	40
4) Basion Bregma (ba-b)	133	16) Orbital Height (OBH)	Left	40.2
			Right	40
5) Cranial Base Length (ba-n)	109	17) Biorbital Br. (ec-ec)		94.1
6) Basion-Prosthion (ba-pr)	89	18) Interorbital Br. (d-d)		24.3
7) Max-Alveolar Br. (ecm-ecm)	59.2	19) Frontal Chord (n-b)		113
8) Max-Alveolar L. (pr-alv)	49	20) Parietal Chord (b-1)		118
9) Biauricular Breadth (alb)	N/A	21) Occipital Chord (l-o)		99
10) Upper Facial Height (n-pr)	66.7	22) Foramen Magnum L. (ba-o)		38.3
11) Min. Frontal Breadth (ft-ft)	92.7	23) Foramen Magnum Br. (FOB)		31.5
12) Upper Facial breadth (fmt-fmt)	106.5	24) Mastoid Length (MDH)	Left	28.2
			Right	28.8

Mandibular Measurements

1) Chin Height (gn-id)		34.1
2) Body Height at Mental Foramen	Left	14.1
	Right	14.3
3) Body Width at Mental Foramen	Left	9
	Right	9.1
4) Bigonial Diameter (go-go)		89.5
5) Bicondylar Br. (cdl-cdl)		111.7

***All measurements in Milimeters**

Appendix B
Postcranial Measurements

Clavicle

1) Maximum Length	Left	143
	Right	151
2) Sagittal Diameter	Left	12.6
	Right	12.4
3) Vertical Diameter	Left	9.4
	Right	9.9

Humerus

1) Maximum Length	Left	320
	Right	304
2) Epicondylar Breadth	Left	58
	Right	N/A
3) Max Diameter at Midshaft	Left	19.4
	Right	21.5
4) Min. Diameter at Midshaft	Left	18.1
	Right	19.4

Radius

1) Maximum Length	Left	239
	Right	240

Ulna

1) Maximum Length	Left	258
	Right	N/A
2) Physiological Length	Left	226
	Right	230
3) Min. Circumference	Left	35
	Right	34

Femur

1) Maximum Length	Left	442
	Right	431
2) Max. Diameter of Head	Left	43.4
	Right	42.5
3) Circumference at Midshaft	Left	88
	Right	87

Tibia

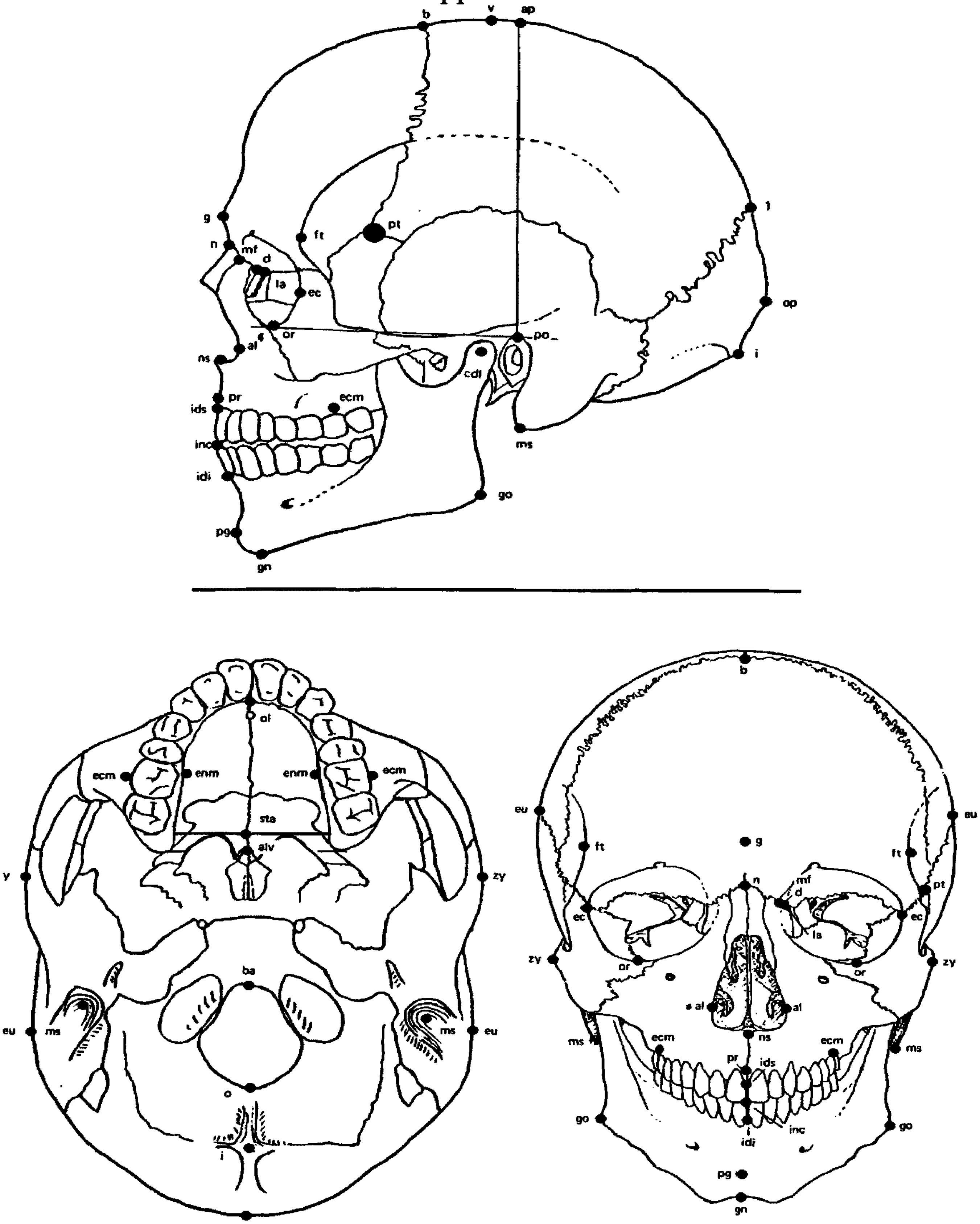
1) Condylo-malleolar Len.	Left	360
	Right	358
2) Max. Diam. Nutrient Foramen	Left	34.5
	Right	32.6
3) Circ. At Nutrient Foramen	Left	93
	Right	92

Calcaneus

1) Maximum Length	Left	N/A
	Right	77

*** All Measurements in Millimeters**

Appendix C



*Anthropometric Locations on the Skull, From Bass 1996: 67-71

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