EVOLUTIONARY FEATURES OF JAWS AND TEETH IN RESPECT TO DIET IN EARLY HOMINIDS.

A RESEARCH PROPOSAL SUBMITTED IN PARTIAL FULFILMENT FOR THE DEGREE OF BACHELORS OF DENTAL SURGERY (BDS) AT THE UNIVERSITY OF NAIROBI.

INVESTIGATOR: PRABLEEN KAUR VIRK
LEVEL III

SUPERVISORS:
INTERNAL: DR. J.R. MUTAVE. BDS (NBI), MRES (UK)
DEPARTMENT OF CONSERVATIVE AND PROSTHETIC DENTISTRY.
SCHOOL OF DENTAL SCIENCES
UNIVERSITY OF NAIROBI.

EXTERNAL: PROFESSOR J. HASSANALI. BDS (EDIN), DDS (EDIN)
DEPARTMENT OF HUMAN ANATOMY
SCHOOL OF MEDICINE
UNIVERSITY OF NAIROBI.

DURATION OF STUDY: APRIL TO OCTOBER 2007
COST OF STUDY: KSH 5,585/= 
SOURCES OF FUNDS: SELF
## TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>TITLE PAGE</td>
<td>i</td>
</tr>
<tr>
<td>LIST OF ABBREVIATIONS</td>
<td>iii</td>
</tr>
<tr>
<td>SUMMARY</td>
<td>iv</td>
</tr>
<tr>
<td>INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>LITERATURE REVIEW</td>
<td>4</td>
</tr>
<tr>
<td>RESEARCH STATEMENT</td>
<td>8</td>
</tr>
<tr>
<td>RESEARCH JUSTIFICATION</td>
<td>8</td>
</tr>
<tr>
<td>OBJECTIVES</td>
<td>8</td>
</tr>
<tr>
<td>HYPOTHESIS</td>
<td>9</td>
</tr>
<tr>
<td>VARIABLES</td>
<td>9</td>
</tr>
<tr>
<td>METHODOLOGY</td>
<td>10</td>
</tr>
<tr>
<td>• Study Area</td>
<td></td>
</tr>
<tr>
<td>• Study Population</td>
<td></td>
</tr>
<tr>
<td>• Study design</td>
<td></td>
</tr>
<tr>
<td>• Sample Size</td>
<td></td>
</tr>
<tr>
<td>• Sampling Process</td>
<td></td>
</tr>
<tr>
<td>DATA COLLECTION MEASUREMENTS AND TECHNIQUES........</td>
<td>11</td>
</tr>
<tr>
<td>• Hominid Skull comparison checklist</td>
<td>11</td>
</tr>
<tr>
<td>• Discussion of variational measurements</td>
<td>11</td>
</tr>
<tr>
<td>• Overall tooth dimensions, Metric Variation</td>
<td>12</td>
</tr>
<tr>
<td>• Instruments</td>
<td>12</td>
</tr>
<tr>
<td>• Data analysis</td>
<td>12</td>
</tr>
<tr>
<td>• Data presentation</td>
<td>12</td>
</tr>
<tr>
<td>RESEARCH LIMITATIONS</td>
<td>13</td>
</tr>
<tr>
<td>EXPECTED BENEFITS</td>
<td>13</td>
</tr>
<tr>
<td>ETHICAL CONSIDERATION</td>
<td>14</td>
</tr>
<tr>
<td>BUDGET</td>
<td>15</td>
</tr>
<tr>
<td>REFERENCES</td>
<td>16</td>
</tr>
</tbody>
</table>
ABBREVIATIONS

BDS: Bachelor of Dental sciences
MRES: Masters in Research
NBI: Nairobi
EDIN: Edinburgh
DDS: Doctorate of Dental Sciences
MYA: Million Years Ago
H.f.: Homo fluorencis
A. anamensis, A. afarensis, A. africanus, A. garhi: A: Australopithecus
H. habilis, H. erectus, H. neandertalis, H. sapien: H: Homo
SUMMARY

Around 7 million years ago ape-like creatures moved away from the forests and began living on the grass-covered plains. As they spent less time in trees and more time traveling across open ground evolutionary pressure favored those with longer legs and they began walking upright. Around one million years ago they learned how to keep fires burning and began cooking their meals. Cooked food required less chewing and so their jaws evolved to become smaller.

It has long been realized that the key trends in human evolution i.e. the things that separate us from our ape cousins and ancestors were:

- **terrestriality** - coming down out of the trees.
- **bipedalism** - having to walk on two feet (obligate, not occasional).
- **encephalization** - increase in brain size in relation to body and development of language.
- **feeding apparatus** - Change in masticatory apparatus in respect to changing diet.

The size, shape, number, construction, location and life span of teeth reflect their function and their evolutionary history. We retain many of the early patterns from the ancient past: the order of eruption, the interdigitation of teeth, the regional specializations of teeth into classes and the replacement of deciduous teeth with permanent successors are among a few of those patterns. Our teeth reflect their evolutionary history.

The word "hominid" refers to members of the family of humans, Hominidae; which consists of all species on our side of the last common ancestor of humans and living apes. The group of early hominids include the Australopithecines, the Homo habilis and the Homo erectus. The Australopithecines existed roughly 2-3 million years ago and for a brief period roamed the earth with the Homo habilis which proved to be the stronger species outliving the Australopithecines. The extinction of the Australopithecine 1 million years ago in the opinion of many palentologists could have been due to a cluster of reasons including inability to cope with change in available diet and a weaker programmed genetic adaptation. As hominids evolved, increasing in body size there was a shift from a predominantly insectivorous to a furgivorous or herbivorous diet, changes also occurred in the shape of the jaw apparatus as well as in the form of individual teeth to compensate for change in diet.

The purpose of this study is to determine the effect of diet on early evolutionary hominins (hunter-gatherers hominids) and the resultant changes in their jaw and teeth size and shape and furthermore to postulate an evidence based conclusion for the reason of extinction of the Australopithecines.

This will be a descriptive cross sectional study using cast replicas of homind jaws and skulls available at the National Museum of Kenya. Data will be collected through detailed skull analysis using a custom made checklist and biometric measurements of the dental arcades, jaw lengths, tooth measurements, dental arch lengths and wear facets. The sample size will depend on the number of casts available. There will be no sampling process employed as the limitation of the number of jaws available denies this tool of unbiased data collection. Therefore all specimens made available will be examined. This
data shall be presented in form of bars, tables and pie charts. Data generated will be entered in a computer and analyzed with SPSS version.

The information collected from this study may be used by interested persons from all fields in discerning the correlation in the jaws and teeth in relation to diet of the early hominid evolutionary species.
INTRODUCTION.

Evolution is thought to begin when there is an error during reproduction and the new cell is different from its parent. Mutant cells usually die, and those that survive are likely to be disadvantaged by their mutation. Only very rarely will a mutant perform better than its parent. The descendents of the mutant cell may then successfully compete against the rest of the population and eventually replace them. The study of life history evolution in hominids is crucial for the discernment of when and why humans have acquired our unique maturational pattern. Because the development of dentition is critically integrated into the life cycle in mammals, the determination of the time and pattern of dental development represents an appropriate method to infer changes in life history variables that occurred during hominid evolution.

The very early history of teeth is not fully known. Teeth are calcified structures derived long ago from dermal denticles during the time in vertebrate history when jaws first evolved. Structurally a tooth consists of a calcified tissue known as dentin which is, at some stage of the life history of the tooth covered by a highly calcified layer of enamel.

<table>
<thead>
<tr>
<th>SPECIES</th>
<th>TIME PERIOD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ardipithicus ramidus</td>
<td>5 to 4 million years ago</td>
</tr>
<tr>
<td>Australopithecus anamensis</td>
<td>4.2 to 3.9 million years ago</td>
</tr>
<tr>
<td>Australopithecus afarensis</td>
<td>4 to 2.7 million years ago</td>
</tr>
<tr>
<td>Australopithecus africanus</td>
<td>3 to 2 million years ago</td>
</tr>
<tr>
<td>Australopithecus robustus</td>
<td>2.2 to 1.6 million years ago</td>
</tr>
<tr>
<td>Homo habilis</td>
<td>2.2 to 1.6 million years ago</td>
</tr>
<tr>
<td>Homo erectus</td>
<td>2.0 to 0.4 million years ago</td>
</tr>
<tr>
<td>Homo sapiens archaic</td>
<td>400 to 200 thousand years ago</td>
</tr>
<tr>
<td>Homo sapiens neandertalensis</td>
<td>200 to 30 thousand years ago</td>
</tr>
<tr>
<td>Homo sapiens sapiens</td>
<td>200 thousand years ago to present</td>
</tr>
</tbody>
</table>
The hominid species have undergone a remarkable and unremitting change in the structure and shape of the jaw and dentition; some up to the present day. The general trend in these changes is for both the jaw and dentition to have become smaller. In fact studies have shown that from about 35,000 years ago until 10,000 years ago tooth size has decreased on average by about one percent every 2000 years. From then until the present the rate has doubled to a one percent decrease every 1000 years (Recent Human Dentition Evolution by Dean et al). All this led to smaller, less projected jaws with small teeth and non-projected canines together with a smaller face. Various evolutionary, environmental, and cultural factors are responsible for this change. It has been noted that there is a decrease in cheek tooth diameters from Homo habilis to Homo erectus to Neanderthals and finally modern Homo sapiens. The Australopithecines display a high level of dental sexual dimorphism based on crown diameter measurements. In anatomically modern Homo sapiens, if male and female canine mesiodistal diameters are plotted together they show a single, asymmetrical mode, but the distribution for Australopithecines is bimodal.

One interesting theory is that dental disease may have been a factor in the selection for smaller teeth and a shorter total dental arch length. Smaller teeth may have fewer crevices, pits and fissures subject to decay. Australopithecine dental arcades tend to be more rectangular than parabolic but in Homo species the dental arcade is a full parabola, broader at the back than at the front. There is also a strong trend in tooth size, such that the cheek teeth of modern humans are smaller than those of australopithecines. Early hominids have obvious crests and ridges on their skulls. The most obvious are the sagittal and nuchal crests and the brow ridges. Whereby in the present skulls the sagittal crests provide anchorage for large chewing muscles and are
thus most prominent in species where the diet comprises hard, tough material requiring a lot of chewing.

In general, the modern human diet contains more meat than that of our early ancestors. This means that over the course of time the teeth were required to process less course vegetable material reducing the need for a large herbivorous dentition. With the development of stone tools humans were basically able to eliminate the need for many carnivorous adaptations by substituting their tools for the sharp teeth, large canines and strong jaws typical of carnivores. When humans began cooking their food (perhaps as early as 200,000 years ago), this made the meat and other foods more tender and easier to chew again reducing the need for a large, robust dentition. [Aiello and Dean 1990].

Evolution has tended to encephalize the brain as time has passed and a larger brain requires a larger braincase to hold it. One of the most efficient means of creating such a larger braincase is to shorten the jaw considering that the usefulness of a large jaw and large dentition at this point is not as advantageous as it once was. Similarly the development of bipedal locomotion created a subtle anatomical shift and an alteration of the braincase that also functioned to reduce the size of the jaw. Because the jaw has shortened so dramatically the back molars are often crowded in the jaw with the result being impacted or misaligned teeth if this problem is not remedied through the use of modern dental technology. The evolution of several behaviors unique to humans resulted in a change of the jaw and dentition. [Radinsky as cited in Hiieiae 1984]. Speculation and work done by dentists, paleontologists and other investigators have helped explain the evolutionary changes observed in the size, shape and position of teeth from early hominids to modern humans. In modern people, third molars have the highest frequency of polymorphism, malposition in the dental arches, impaction and agenesis. Approximately 65 percent of the human population has at least one impacted third molar at 20 years of age and third molars that do erupt frequently are mal-posed in the arches and consequently are difficult to clean. These aberrations in third molar patterning may be related to the shortening of the jaws that occurred in people over time. Prehistoric people likely did not have the infections we associated today with impacted and partially impacted third molars. Although caries and periodontal disease were prevalent, evidence suggests that dental pathology was relatively low. The disintegration of the dentition in prehistoric people appears to have been primarily the result of extreme occlusal wear and its accompanying sequelae. Third molars therefore may have played a useful role in decreasing the rate of occlusal wear by increasing the surface area available for chewing. [Anthony R. Silvestri Jr. and Iqbal singh]

One of the most important is the development of language, which requires dramatically altered and flexible oral structures. The evolution of speech was associated with changes in the base of the braincase and the pharynx, both of which indirectly affect the jaw and dentition. [Hiieiae 1984].
LITERATURE REVIEW

The following are brief descriptions of the hominid evolutionary genus and the corresponding species according to numerous studies coalesced and summarized:

1. **Australopithecines**: African hominids which include: *anamensis*, *afarensis* and *africanus* appeared more than four million years ago and seemed to have died out about 2.4 million years ago.

   *A. afarensis* existed between 3.9 and 3.0 million years ago. Afarensis had an apelike face with a low forehead, a bony ridge over the eyes, a flat nose and no chin. They had protruding jaws with large back teeth. Cranial capacity varied from about 375 to 550 cc. The dentition of afarensis retained primitive apelike features. The jaws were comparatively large and prognathous. The dental arch in the upper was 'omega' shaped and in the lower it was V-shaped. The skull was similar to that of a chimpanzee except for the more humanlike teeth. The teeth were large, but did not present the extremes seen in Paranthropus. The canines projected beyond the occlusal plane and were much smaller than those of modern apes, but larger and more pointed than those of humans. Diastema distal to the maxillary lateral incisors was present. The mandibular first premolar is described in the literature as 'commonly unicuspid. However their pelvis and leg bones far more closely resembled those of modern man and leave no doubt that they were bipedal (although adapted to walking rather than running (Leakey 1994)). Their bones showed that they were physically very strong. Females were substantially smaller than males, a condition known as sexual dimorphism. Height varied between about 107 cm (3'6") and 152 cm (5'0"). The finger and toe bones were curved and proportionally longer than in humans, but the hands were similar to humans in most other details (Johanson and Edey 1981). Most scientists consider this evidence that afarensis was still partially adapted to climbing in trees whilst others consider it evolutionary baggage.

*A. africanus* existed between 3 and 2 million years ago. It was similar to afarensis and was also bipedal but body size was slightly greater. Brain size may also have been slightly larger ranging between 420 and 500 cc. This is a little larger than chimp brains (despite a similar body size) but still not advanced in the areas necessary for speech. The back teeth were a little bigger than in afarensis. Although the teeth and jaws of africanus were much larger than those of humans, they were far more similar to human teeth than to those of apes (Johanson and Edey 1981). The shape of the jaw was fully parabolic like that of humans and the size of the canine teeth was further reduced and barely projected beyond the occlusal plane compared to afarensis. The incisors were spatulate and vertically implanted in the jaws. There was no maxillary diastema between the incisors and canines. The mandibular first premolar was described as 'bicuspid.' The molars were larger than in later hominids but morphologically were very similar to those of the Homo.

*A. anamensis* was named in August 1995 (Leakey et al. 1995). The material consisted of 9 fossils mostly found in 1994 from Kanapoi in Kenya and 12 fossils, mostly teeth found in 1988 from Allia Bay in Kenya (Leakey et al. 1995). Anamensis existed between 4.2 and 3.9 million years ago and had a mixture of primitive features in the skull and advanced features in the body. The teeth and jaws were very similar to those of older fossil apes. A partial tibia was strong evidence of bipedality and a lower humerus was extremely humanlike.
Other Australopithecine species include: 

*A. garhi* which was named in April 1999 (Asfaw et al. 1999). It was known from a partial skull. The skull differed from previous australopithecine species in the combination of its features; notably the extremely large size of its teeth especially the rear ones and a primitive skull morphology (Groves 1999; Culotta 1999).

*A. aethiopicus* existed between 2.6 and 2.3 million years ago. This species was known from one major specimen; the Black Skull discovered by Alan Walker and a few other minor specimens which may have belonged to the same species. It may have been an ancestor of robustus and boisei but it had a baffling mixture of primitive and advanced traits. The brain size was very small at 410 cc. Parts of the skull particularly the hind portions were very primitive mostly resembling afarensis. Other characteristics like the massiveness of the face, jaws, single tooth found, and the largest sagittal crest in any known hominid were more reminiscent of *A. boisei* (Leakey and Lewin 1992).

*A. robustus* had a body similar to that of africanus but a larger and more robust skull and teeth. It existed between 2 and 1.5 million years ago. The massive face was flat or dished with no forehead and large brow ridges. It had relatively small front teeth but massive grinding teeth in a large lower jaw. Most specimens had sagittal crests. Its diet would have been mostly coarse, tough food that needed a lot of chewing. The average brain size was about 530 cc. Bones excavated with robustus skeletons indicate that they may have been used as digging tools.

*A. boisei* existed between 2.1 and 1.1 million years ago. It was similar to robustus but the face and cheek teeth were even more massive with some molars being up to 2 cm across. The brain size was very similar to robustus of about 530 cc. A few experts consider boisei and robustus to be variants of the same species.

Australopithecines were principally vegetarians that became extinct 1 million years ago. Australopithecus afarensis and africanus and the other species above are known as gracile australopithecines because of their relatively lighter build, especially in the skull and teeth. (Gracile means "slender" and in paleoanthropology is used as an antonym to "robust"). Despite this they were still more robust than modern humans. Australopithecus aethiopicus, robustus and boisei are known as robust australopithecines, because their skulls in particular are more heavily built. They have never been serious candidates for being direct human ancestors. Many authorities now classify them in the genus Paranthropus. They are known for their large cheek teeth and well developed chewing musculature. The skulls of Paranthropus have prominent sagittal and nuchal crests associated with maximizing attachment areas for masticatory musculature. The term *robust* applies to those exaggerated skeletal and dental characteristics. Mary Leakey described her find of a Paranthropus in East Africa (Tanzania) as 'Nutcracker Man.'

Paranthropus dental characteristics are distinctive. The incisor teeth are similar to africanus; however the cheek teeth of Paranthropus are much larger than the anteriors. The premolars are molariform. The cheek teeth also had a thick covering of enamel and were subjected to considerable wear, implying a tough vegetarian diet. The heavy reinforcement of the face and the large attachments for the masticatory muscles confirm the tough diet.

These robust hominids had massively built skulls and remarkably large cheek (premolars and molars) teeth. In the fossils found in the East Africa region bucco lingual diameters of 22 mm have been recorded for lower third molars. Their anterior teeth in contrast are within the size range of our own Homo sapien skulls.
The molars and premolars are enormous when compared to the incisors and canines. They are broad when compared to those of the Australopithecines. Maxillary third molars display wrinkled enamel a characteristic seen in the great apes.

2. **Homo** evolved in Africa 2.5 Million years ago and subsequently spread out around the world.

**Homo habilis:** "handy man", was so called because of evidence of tools found with its remains. Habilis existed between 2.4 and 1.5 million years ago. This species co-existed with the Australopithecines for some time before emerging as the stronger species that outlived the other. It was very similar to australopithecines in many ways. The face was still primitive but it projected less than in A. africanus. The back teeth were smaller but still considerably larger than in modern humans. The average brain size at 650 cc was considerably larger than in australopithecines. Brain size varied between 500 and 800 cc, overlapping the australopithecines at the low end and H. erectus at the high end. The brain shape was also more humanlike. The bulge of Broca's area, essential for speech was visible in one habilis brain cast and indicates it was possibly capable of rudimentary speech. Habilis is thought to have been about 127 cm (5'0") tall and about 45 kg (100 lb) in weight although females may have been smaller.

H. habilis is considered to have been a more efficient biped than the Australopithecines. Most significant was its manufacture and use of stone tools. It had parabolic dental arches, small canines, no diastema, and a feature peculiar to H. habilis specimens: the relatively narrower (bucco-lingually) human-like cheek teeth. They also had reduced molar and premolar sizes like the other Homo species.

**Homo erectus** existed between 1.8 million and 300,000 years ago. Like habilis, the face had protruding jaws with large molars, no chin, thick brow ridges and a long low skull with a brain size varying between 750 and 1225 cc. Early erectus specimens average about 900 cc while late ones have an average of about 1100 cc (Leakey 1994). The skeleton was more robust than those of modern humans implying greater strength. Body proportions varied; the Turkana Boy was tall and slender (though still extraordinarily strong) like modern humans from the same area, while the few limb bones found of Peking Man indicate a shorter, sturdier build. Study of the Turkana Boy skeleton indicates that erectus may have been more efficient at walking than modern humans, whose skeletons have had to adapt to allow for the birth of larger-brained infants (Willis 1989). Homo habilis and all the australopithecines are found only in Africa but erectus was wide-ranging and has been found in Africa, Asia, and Europe. There is evidence that erectus probably used fire and their stone tools were more sophisticated than those of habilis.

H. habilis is the first hominid with a wide distribution out of Africa into much of the Old World. The dentition of H. erectus was essentially similar to that of modern man. Its dental arch was parabolic. Compared to modern mans dentition the teeth are seen as larger, the maxillary central incisors are shovel-shaped, the canines are more robust, cingula are seen around the cheek teeth and there may be some wrinkling of the enamel.

The mandibular second and third molars tended to possess five cusps (dryopethicus) rather than four cusps.

There I was some degree of taurodontism wherein the pulp chamber extends well into the roots.

3. **Neandertals** are also frequently identified as Archaic Homo sapiens.
Their teeth were positioned more anteriorly than Homo sapiens so that there was a retromolar space distal to the third molars and anterior to the anterior border of the ramus. Anterior teeth were comparatively large. The molars were often taurodont, with the pulp chambers extending well into the root area.

The apparent great emphasis on the use of the anterior dentition resulted in a substantial mid facial prognathism. The anterior teeth in many specimens exhibit wear patterns consistent with use of those teeth in softening animal hides.

4. **Homo sapiens** present with jaws that are less robust and the teeth a little smaller. There is a well-documented trend of dental reduction in the last 40,000 years.
1.1 RESEARCH STATEMENT

Dental Anthropology is the study of teeth in a perspective beyond clinical science. That perspective includes the study of dental growth, theories on dental origin, primate dentition, and population variation. Several studies on evolution indicate several trends, including changes in posture, cranial capacity (brain size), jaw size and shape, facial angle and dimensions and shape of dentition of the hominid skull.

1.2 RESEARCH JUSTIFICATION.

According to Roy Lewis in *The Evolution of Man*, an evolving mammal worries about nothing more than it does its teeth and similarly to a palaeontologist, nothing about a mammal matters more than its teeth. So in light of this evolutionary change of the hominid jaw and dentition this prevails as a subject of marked interest. The gradual changes in these characteristics cannot be ignored as ‘coincidence’ or unfounded as many dental anthropologists have carefully uncovered proof of such evolutionary changes.

Furthermore it would be to every dentist or dental students advantage to have some knowledge of why human dentition presents the way it does today. As Nina Mehta an acclaimed writer said ‘You don’t know where you’re going till you know where you came from.’

1.3 OBJECTIVES.

1.3.1 Main objectives.

To determine the pattern of evolutionary changes in morphology, function and size of the early hominid jaw and dentition in respect to diet and cranial capacity over the 5 million years of evolution.

1.3.2 Specific objectives.

1) To compare dental arcades and dentition of the early hominid evolutionary skulls and to determine if there is a correlation between the species.
2) To determine if there has been any change in predominant diet, cranial capacity, jaw morphology, prognathism and sagittal crests.
3) To determine if there is a functional relationship between diet and tooth biometry through evolution.
1.4 HYPOTHESES

1. There is a significant change in the shape and size of the early hominid jaws and teeth in relation to change in diet and cranial capacity.
2. The Australopithecines were outlived by the Homo genus which displayed remarkable cranial metamorphosis and adaptation to diet.

1.5 VARIABLES

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>MEASUREMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Independent variables</strong></td>
<td></td>
</tr>
<tr>
<td>• Hominid species</td>
<td></td>
</tr>
<tr>
<td>• Predominant diet, Habitat</td>
<td></td>
</tr>
<tr>
<td><strong>Dependant variables</strong></td>
<td></td>
</tr>
<tr>
<td>• Cranial capacity</td>
<td>Size of brain measured in cc</td>
</tr>
<tr>
<td>• Tooth measurements</td>
<td>Selected individual tooth parameters- mesiodistal length, Buccolinguinal width and crown height. Including dental arch length (combined width of anterior and cheek teeth)</td>
</tr>
<tr>
<td>• Jaw length, Prognathism and Dental arcade</td>
<td>Measuring maxilla and mandible length and shape of arch of jaw respectively</td>
</tr>
<tr>
<td>• Wear facets</td>
<td>Whether there is evidence of wear- attrition, abrasion, abrisfaction or occlusion wear.</td>
</tr>
</tbody>
</table>
2.0 METHODOLOGY

Study area
The study will be conducted in Nairobi at The National Museum of Kenya; a building of tribute and learning that displays the country's natural geographical, historical, ecological, cultural, political and paleoanthropological collection. It is situated at Museum hill Roundabout.

Study population
Study involving hominid evolutionary cast models that have been preserved at The National museum of Kenya.

2.3 Inclusion criteria
Early hominid species (Australopithecines, Homo habilis and Homo erectus) model casts that are relatively intact and will most likely not compromise the precision of measurements.

2.4 Exclusion criteria
Casts of evolutionary species out of the 1-4 million year time frame, casts of other primates and incomplete early hominid casts that will yield unreliable results.

2.5 Study design
This will be a descriptive cross sectional study

2.6 Sample size
Due to the limited amount of evolutionary fossils available in the country all intact and near complete available fossils and casts will be used.

2.7 Sampling process
Since the number of fossils is so limited each and every skull available will be used for the purposes of this project.
DATA COLLECTION INSTRUMENTS AND TECHNIQUES.

3.1 Method
Each fossil or cast will be analyzed and measured according to the following checklist:

HOMINOID SKULL COMPARISON CHECKLIST. All measurements in [mm]

1. Sagittal crest: (The bony ridge along the top of the skull to which large chewing muscles attach.) Is there a sagittal crest present? How pronounced is it? is it large, small, or medium?
2. Prognathism: Each skull will be examined for existence of a "muzzle" or snout - a protrusion of parts of the face below the eyes.
3. Maxilla length: Measurements down the middle of the palate from the front edge of the foramen magnum to either between or just in front of the two central incisors will be made to determine how much the face projects forward.
4. Bizygomatic breadth: The width or breadth of the face from the widest part of one zygomatic arch to the widest part of the other zygomatic arch.
5. Dental arcade: The arch or shape of the jaw will be assessed to be either boxshaped (sides parallel), "U"-shaped (parabolic sides), " V " -shaped, or intermediate.
6. Number of teeth: Top/Bottom: The number of teeth in the upper and lower jaw will be counted and noted. The number of incisors, canine, premolars and molars in one-half of the upper jaw as the numerator and the same count for one-half of the lower jaw as the denominator will be noted.
7. Incisors: When viewed from the side the incisors will be noted to be angled out or vertical. The combined width or breadth of the 4 incisors together will be measured.
8. Canines: Will be noted to be either long or short and sharp or dull? Presence of a diastema will also be noted (a gap between the upper incisors and canines).
9. Cheek teeth: combined length of the 2 premolars and 3 molars will be measured using callipers
10. Cranial Module: The maximum length will be measured by placing one end of a calliper on the most forward projecting point of the forehead and the other end on the most posterior point at the back of the skull. The maximum width will be determined with the callipers on the sides (temples) of the skull at the widest point. The maximum height will be measured by putting the skull on its side; then holding one end of the callipers on the midpoint anterior to the foramen magnum and the other end at the intersection of the coronal and sagittal sutures on top in the midline. These will then be added and divided by 3.
11. Individual selected tooth measurements:
   i. Mesiodistal measurements.
   ii. Buccolingual measurements.
   iii. Crown height.

Variational measurements discussed:
Metric variation is evaluated by making measurements of teeth.
Non-metric variation is the subjective judgement of certain features. One feature well known to clinicians is the Carabelli trait. Another non-metric feature is the shovel-shaped incisor.
Overall Tooth Dimensions, Metric Variation

The familiar maximum measurements of the teeth are the ones most commonly used.

1. **Mesiodistal** measurement called *crown diameter* is often used. Proximal wear reduces this dimension and introduces statistical error. This is taken as the greatest mesiodistal dimension taken parallel to the occlusal and facial surface. The measurement is typically taken using calipers with arms machined to a fine point. There is a difficulty with proximal wear therefore most researchers exclude teeth with marked proximal wear. If occlusal attrition is excessive the accepted practice is to exclude heavily worn teeth.

2. **Buccolingual** measurements are unaffected by proximal wear but become inaccurate in excessively worn teeth. This measurement is the greatest distance between the facial and lingual surfaces of the crown taken at right angles to the plane in which the mesiodistal diameter is taken. It is easiest to use calipers which have broad, flat surfaces. Buccolingual diameters are unaffected by approximal wear but can become unusable when occlusal wear is excessive.

3. **Crown height** measurements are most affected by wear and are therefore the least useful in population studies. This is defined as the distance from the tip of the highest cusp to the cervical line on the buccal side. Any occlusal wear at all renders this measurement unreliable; therefore it is seldom employed.

   For one population and a single sex, the mesiodistal and buccolingual diameters of each tooth type have normal (Gaussian) distributions. This is usual for the dimensions of anatomical structures in adults and is true of skeletal measurements as well. This project will probably deviate from the ideal of normality but this is to be expected with small numbers of specimens and their uncertain derivation.

   In modern humans there is a moderate correlation between mesiodistal and buccolingual diameters. Those correlations are slightly greater in females than males, in upper than lower teeth and in cheek teeth than anterior teeth. Correlations for diameters between different teeth in the same jaw are moderate for both permanent and deciduous teeth.

3.2 **Instruments**

   1. Protractors.
   2. Rulers and measuring tape.
   3. Calipers (Sliding or hinge calipers).
   4. Calibrated dividers
   5. Flexible tape

3.3 **Data analysis**

   The checklist results will be coded and the data processed with statistical package for social sciences (SPSS) 12.0 (SPSS include Chicago, Illinois USA).

   Descriptive analysis will be used to describe the data.

   Cross tabulation will be used to compare different variables.

3.4 **Data presentation**

   The data will be presented in form of tables, charts and bar graphs.
3.5 Research limitations
This study is neither an experiment nor a planned observation but an analysis of preexisting records and a few available fossil skulls to determine how evolution affected the size, shape and function of the human jaw and teeth. Problems that most likely will arise in the course of this research project therefore are:

1. Determining accurate measurements from the cast models as they are replicas and not the actual fossilized specimens and furthermore we have to contend with infrequent fossilization, fragmentary remains and challenges of taphonomy (changes that occur to organisms after being buried) that are replicated on the casts.
2. While measuring the casts there is likely to be some amount of error in exacting the actual measurements as has been the case in other similar projects, leading to inter and intra-personal discrepancies in the results.
3. Formulating a hominid skull checklist and being able to adhere to it because some model casts from the fossil skulls may not be completely intact.
4. Becoming familiar with the different tools (handle and read the measuring instruments) and techniques used in paleoanthropological studies and to acquire some of these instruments that may not be too readily available in Kenya.
5. The sample size will not be too large and therefore the chances of errors and derisory results are higher.
6. This research topic will be time-consuming in terms of literature review and ample data collection and at the same time costly as unexpected expenses may arise.
7. Sampling cannot be a luxury as each fossil attained will have to be studied and analyzed therefore once again increasing the risk of erroneous results as taking meticulous results will be difficult due to lack of skill.

3.6 Expected benefits
1. An evidence based answer to why the Australopithecine genus became extinct can be drawn from the results of this project.
2. Changes in the early hominid jaws and teeth with change in diet will help interested researchers postulate how the present hominid jaw and teeth will evolve with time.
3. Individuals interested in dental anthropology may use this report as a guideline on learning about evolutionary changes in the hominid skull jaw and teeth over the last one to four million years.
4. The checklist and format of this report may be used by other hominid evolutionary researchers as a reference guide and base line data.
5. During the course of this study patterns of other variable features about the hominid jaw and teeth can also be determined e.g. peg shaped lateral incisors, missing lateral incisors and premolars etc
6. Organizations or individuals researching on the same topic may use this report as a comparative study, critique or reference source.
7. If some objectives are positively conclusive e.g. if third molars are truly vestiges then more light should be shed on the issue of early extractions and consequences.
8. Report to be used in partial fulfillment for a Bachelor of Dental Surgery degree at the University of Nairobi.
3.7 **Ethical consideration**
Proposal will be submitted to the University of Nairobi Ethics, Research and Standards for approval. Permission will be sought from the relevant authorities. The purpose of the study, the expected benefits and risks will be explained to the authorities. The hominid skulls will be handled with utmost care ensuring that there will be no damage and at no point will the preservation state of the skulls be compromised.
### 3.8 BUDGET

#### Stationary

<table>
<thead>
<tr>
<th>Items</th>
<th>Quantity</th>
<th>Ksh.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Pens</td>
<td>10 @ 10</td>
<td>100/=</td>
</tr>
<tr>
<td>2. Writing materials</td>
<td>1 rim @ 300</td>
<td>300/=</td>
</tr>
<tr>
<td>3. Calculator</td>
<td>1 @ 50</td>
<td>150/=</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sub-Total 550/=</td>
</tr>
</tbody>
</table>

#### Instruments

<table>
<thead>
<tr>
<th>Items</th>
<th>Quantity</th>
<th>Ksh.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Rulers</td>
<td>3 @ 20</td>
<td>60/=</td>
</tr>
<tr>
<td>2. Calipers</td>
<td>1 @ 1200</td>
<td>1200/=</td>
</tr>
<tr>
<td>3. Measuring tape</td>
<td>1 @ 250</td>
<td>250/=</td>
</tr>
<tr>
<td>4. Protractors</td>
<td>3 @ 15</td>
<td>45/=</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sub-Total 1555/=</td>
</tr>
</tbody>
</table>

#### Literature search

<table>
<thead>
<tr>
<th>Items</th>
<th>Quantity</th>
<th>Ksh.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Internet browsing</td>
<td>1/= per minute</td>
<td>500/=</td>
</tr>
<tr>
<td>2. Anthropology textbook by Kottak</td>
<td>1 @ 1500</td>
<td>1500/=</td>
</tr>
<tr>
<td>3. Library books</td>
<td>12 @ 20</td>
<td>240/=</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sub-Total 2240/=</td>
</tr>
</tbody>
</table>

#### Typing, Printing, Photocopying and Binding

<table>
<thead>
<tr>
<th>Items</th>
<th>Quantity</th>
<th>Ksh.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Proposal typing</td>
<td>20 pages @ 15</td>
<td>300/=</td>
</tr>
<tr>
<td>2. Printing</td>
<td>25 pages @ 10</td>
<td>250/=</td>
</tr>
<tr>
<td>3. Checklist forms</td>
<td>50 @ 10</td>
<td>500/=</td>
</tr>
<tr>
<td>4. Photocopying</td>
<td>20 pages @ 2</td>
<td>40/=</td>
</tr>
<tr>
<td>5. Binding</td>
<td>3 copies @ 50</td>
<td>150/=</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sub-Total 1240/=</td>
</tr>
</tbody>
</table>

**TOTAL** 5,585/=
4.0 REFERENCES

1) Anthro.palomar.edu – accessed on 05.05.07


5) Butler, P. M. *Anthropology* 1956; 31; 30-70


7) Dental Anatomy and Embryology by J W Osbourn. Volume 1, Book 2; 357-398.

8) Dental Anthropology by Simon Hilson. Volume 2: 21-134


16) Members.aol.com- accessed on 05.05.07


20) www.anth.ucsb.edu/projects - accessed on 08.04.07

21) www.channel4.com – accessed on 07.04.07

22) www.emory.edu – accessed on 05.05.07

23) www.mnh.si.edu/anthro/humanorigins/ha/nead_sap_comp.html - accessed on 25.03.07

24) www.pbs.org/wgbh/nova/neanderthals/skulls.html - accessed on 07.04.07

25) www.scotese.com – accessed on 08.04.07

26) www.talkorigins.org/faqs/homs/savage.html - accessed on 07.04.07