A man ceases to be a beginner in any given science and becomes a master in that science when he has learned that he is going to be a beginner all his life.

A man should look for what is, and not for what he thinks should be.

Robin G. Collingwood & Albert Einstein

Chapter 1: Introduction

1.1. General

On the 30th May 2006 at 15h30, a gentleman collecting fire wood in a veldt in Moffat Park in the South of Johannesburg came across some bones. Not sure whether the bones were that of an animal or human, he contacted the South African Police Services (SAPS). The SAPS then contacted the Johannesburg Forensic Pathology Service who confirmed that the skeletal remains were indeed those of a human and not an animal. The site was cordoned off and the body was exhumed the following day (1, 2).

On the 1st of June, a post mortem examination was performed on the remains. The main post mortem examination findings were that the remains were those of a young adult, black female found in a grave measuring approximately 1.68 m in length and 45 cm to 50 cm in depth. The grave was covered with bricks and the soil was dry and contained a small amount of refuse material. The area in which the body was found had recently been burnt a in veldt fire (Figures 1.1 and 1.2) (1, 2).

Figure 1.1. Scene where the body was found. Note the burning in the area. **

Figure 1.2. Close up picture of how the body was observed in the shallow grave. **

** **Footnote:** Ethical clearance was obtained for this study (Ethics clearance number 32/ 2006), but in order to protect the identity of the individuals (cadavers) in the photographs, the ethics committee stipulated that only parts of faces may be revealed due to the sensitive nature of these images. For this reason, complete images of the individuals used in this study will not be shown anywhere. However, in this introduction section, unedited South African Police Service case images have been used without an attempt to protect the identity of the individual in the photographs, as this case has been finalized in the legal system. It was also agreed that the crime scene photographs would be used without editing in this thesis, but not used in any publications which may potentially arise from this study.

The deceased was found lying on her left side with her left arm under her body. A portion of her right arm and right ribs had been scorched. Signs of insect activity were evident on the remains and large amounts of maggots were present which were collected for further evaluation. A red school blazer was found with the deceased and partially covered her head. The skeletal remains had minimal decomposed, saponified tissue over the entire body. The skull was covered with long African hair with a head band over the vault of the skull. The skull and mandible were intact, all dentition was present, the hyoid bone was intact and the long bones that were identified showed no signs of ante mortem injury. Scorched remains of the right arm, hand, thoracic ribs and ilium were present (Figures 1.3 and 1.4) (1, 2).

The pathologist estimated that the remains were those of a black female, approximately between the ages of 16 and 20 years with an estimated living stature of 1. 65 to 1. 68 metres tall. Cause of death could not be ascertained due to the advanced stage of decomposition of the remains. The remains were sent to the anthropologists at the Department of Anatomy, University of Pretoria for Anthropological examination and an attempt to determine identity (1).

On analysis, the anthropologist established a similar demographic profile to the pathologist: a black female between the ages of 16 and 23 years with an estimated living stature of 162 cm. The anthropologist also found a peri-mortem fracture to the right tibia which probably occurred at the time of the young female's death (1, 2).

Personal items such as the red school blazer and a key found in the blazer pocket were used as leading factors in the efforts to identify the young female. The school which had the red blazer as part of their uniform was contacted to enquire about any missing learners.

They confirmed that a learner was in fact missing and the possible identity of the deceased was thus investigated.

Figure 1.3. The appearance of the remains after removal from the shallow grave.

Figure 1.4. The victim lying on her left side, skeletonised, with African hair present.

A photograph of the missing young schoolgirl was obtained and skull-photo superimposition was performed on the skull, in order to establish identity (Figure 1.5) (1).

Figure 1.5. Results of the skull-photo superimposition (left) and a recent school photograph of the young girl shortly before her murder (right).

Figures 1.6 – 1.8 show the process of skull-photo superimposition as it is carried out to establish whether the skull and photograph match. A mixing device is used to provide the image of the skull and photograph together, with different sweeping manoeuvres to see if features of the skull and face are a match.

The biological mother of the missing schoolgirl was also approached for a DNA sample which was provided. Comparative DNA analysis and skull-photo superimposition proved the identity of the human remains to be those of the missing schoolgirl, beyond any doubt (1, 2).

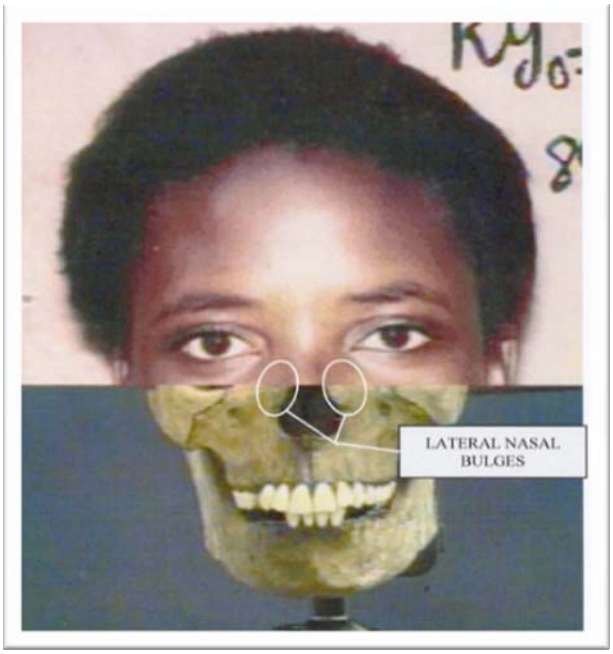

Figure 1.6. Results of skull-photo superimposition- top to bottom sweep identifying areas that match.

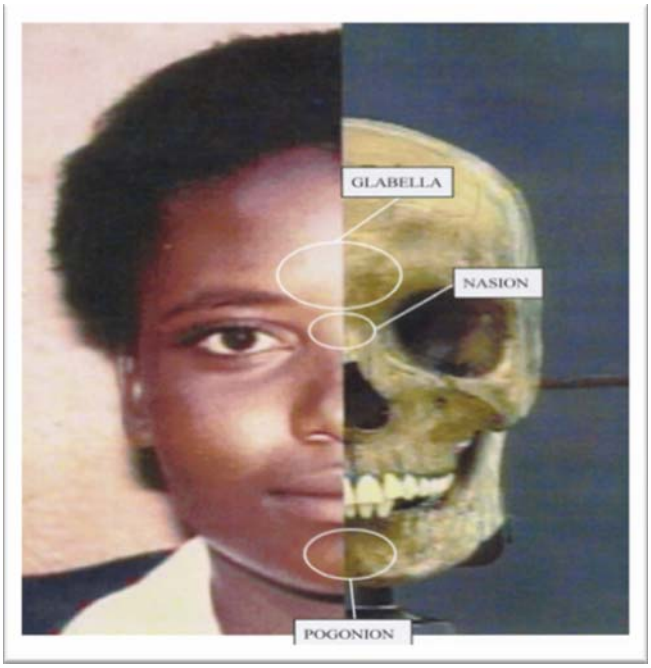

Figure 1.7. Results of skull-photo superimposition- left to right sweep midline identifying areas that match.

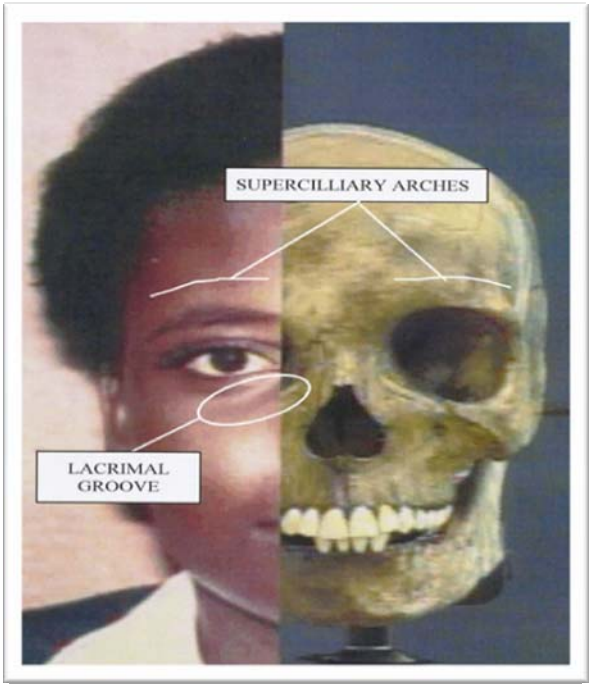

Figure 1.8. Results of skull-photo superimposition- left to right sweep lateral one third of face identifying bony areas that match.

Sadly, this young girl had been one of the five victims of the "Moffat Park Serial Murderer" Gcnumuzi Richard Makhwenkwe who was convicted of 11 counts including rape, murder and robbery with aggravating circumstances. This girl had been Makhwenkwe's third victim and it was after the discovery of her remains (two bodies with similar manners of concealment had been found previously) that the SAPS suspected a serial murderer on the prowl. Makhwenkwe was ultimately identified as the Moffat Park serial murderer as he had murdered one of his ex-girlfriends and her boyfriend and with the help of a witness, it was established that he was the last person she was seen alive with. He confessed to all five murders and was able to point out the locations where he disposed of the remains. He also confessed to raping two women prior to these murders, but not to murdering them (1, 2).

As can be seen above, numerous areas of forensic scientific investigative processes were utilised in the identification and prosecution of Gcnumuzi Richard Makhwenkwe as well as the identification of his victims. Of particular importance here was the use of comparative DNA analysis and skull-photo superimposition to identify this particular victim. Only the remains of the schoolgirl victim were skeletonised- the remains of the other four victims were at varying stages of decomposition, but visual facial identifications could still be done. This case illustrates the use of skull-photo superimposition and the role it can play in identifying unknown victims of crime, particularly where other forensic scientific comparative identification techniques cannot be utilised, due to lack (or absence) of comparative samples.

One of the aims of forensic sciences is to rebuild crime scenes so as to establish the sequence of events that led up to the investigation (3). When the crime scene involves a victim that is deceased, the investigator needs to establish who the victim was and the circumstances leading to the victim's death. There are, however, cases where the remains are skeletonised and so the determination of the identity of the victim is more difficult. Forensic anthropologists have to rely on skeletal characteristics to determine the identity (4).

When skeletal remains are found the first fact that needs to be ascertained is whether the remains are those of an animal or human. Once it is confirmed that the remains are human, the anthropologist or pathologist is tasked with developing a demographic profile of the deceased that can potentially be matched to a missing person's profile. Here the anthropologist plays a key role. If the possible identity of the human remains cannot be determined, then a potential crime cannot be investigated. This is of particular importance in South Africa where hundreds of unidentified bodies (including skeletonised remains) who may have been victims of homicidal crimes, are buried as paupers every month (5). When skeletal remains are located, it is the role of the anthropologist to try and establish the identity of the individual(s). The post mortem interval

must also be estimated and the bones of the skeletonised remains must be anatomically identified. A biological profile is established for the set of remains which should include the sex of the individual, their stature, their age and their population affinity. These features give authorities a broad idea of who to look for when investigating the missing person's profiles. Factors of individualisation are features that can be seen with the remains which provide clues to the exact identity of the individual. Dental records, old or healed trauma on a bone and dental mutilations are specific to an individual and therefore assist with the identification (5). The skull with facial features could also be used as a factor of individualisation. Therefore where two or more sets of remains are present, skull-photo superimposition could be used to identify specific individuals.

In most countries ante mortem dental records or DNA are used to identify victims (6-8). However, should these be unavailable or unsuccessful (9) other methods should be used. Skull-photo superimposition is an additional method that could be used to identify skeletal remains (or to exclude persons) based on the individual characteristics that can be observed from the skull. In such cases the investigators need to have an idea as to the possible identity of the victim. Ante mortem photographs are then used in order to try and establish identity, or to exclude individuals (10). This is done through skull-photo superimposition. In this procedure, the photograph of the suspected victim is superimposed over the skull. Video and photographic equipment is used in order to establish whether the particular skull and skeletal remains are those of the individual in the photograph (10-12). Photographic superimposition has proved to be highly valuable in the identification process of skeletonised remains (13, 14).

The basis for craniofacial identification is the distinctive individuality of the human skull (15). The reliability of identifying a skull as belonging to a particular person increases when there are unique characteristics or irregularities on the skull.

Morphological and metric analyses are initially carried out on the skull (where possible), in order to establish general demographic characteristics such as sex and age. These findings are then combined and assessed to obtain a preliminary identity before the superimposition is done (16). The use of craniometric points has further aided in craniofacial identification. These craniometric points have been used in conjunction with a coordinate system to provide detailed information about the distances, angles and spatial relationship between these points. This has enabled the matching of a skull to a photograph as well as the comparison of two skulls to assess any similarities that may be evident (15).

There are two techniques that have been used to carry out facial feature identification from the skull, namely skull-photo superimposition and facial reconstruction or facial approximation. Facial reconstruction is a method which utilises the knowledge of facial anatomy and skin tissue thicknesses, whereby clay is used to build up the facial profile of a skull (17). This, however, can only be used to draw the public's attention in order to obtain initial clues as the identity of the person, and cannot be used as proof of identity in court. Skull-photo superimposition uses a skull or image of a skull or x-ray, onto which an ante-mortem photograph of the suspected deceased individual is superimposed to examine whether there is a match between the facial features and the anatomical landmarks (11, 18, 19). The anatomical landmarks of the skull need to align with the size and configuration of the photograph in order to make a match. Disparities between anatomical landmarks, size and configuration can also be seen, so that the individual can be eliminated as being the suspected victim (13, 14).

Photographic superimpositions of areas of the maxillary bone and dentition can also be carried out to determine whether there is a match in the dentition, should no other bone fragments be available. This was effectively done in a case of an air force pilot whose plane crashed in Vietnam, where the maxillary remains (minus teeth) provided identification (20).

Due to problems with personal identification in South Africa (5, 21) and high crime rates, this procedure is commonly used in this country. Although some reports on reliability have been published (6, 15, 22-26) its accuracy has never been tested in a consistent manner and also not on a South African population. Questions that may arise in presenting this type of evidence in court, would include issues of the reliability and accuracy of the technique, i.e. what the possibilities are that a positive match might in fact not be positive, what the possibilities are that a negative result (exclusion) might indeed have been a match, and how many other individuals could have been positively matched to a particular skull/photograph.

1.2. Aims and objectives of the study

The objectives of this study are to establish the accuracy of the skull-photo superimposition technique on a South African sample in order to determine whether the technique is suitable for use in the South African legal system. This study will also evaluate whether carrying out the technique digitally enhances the technique and make it faster to perform than the current method as used in South Africa.

The aims of this study are:

1. To carry out skull-photo superimpositions using computer software to digitize the technique, to assist in minimizing the difficulties with the orientation, sizing and the time taken to achieve this. This is very similar to the technique currently used in South Africa, however, it will be an improved technique which is totally computer based.
2. To establish firm criteria (similar to how finger printing is carried out) that confirm a match or a non-match between a skull and photograph and aims to eliminate

subjectivity in the method. This will be done through comparing landmarks on the skull and photograph.

3. To establish the possibilities of false positive identification and false exclusion, using a large number of superimpositions. These superimpositions will include both skulls that match a particular photograph and skulls that do not match a particular photograph.
4. To compare the accuracies of superimposition done by traditional morphological matching and a landmark based approach.
5. To establish criteria for a best-practice procedure that can be used in future superimpositions in South Africa and elsewhere around the world so that consistent procedures are used for the technique worldwide.

1.3. Hypothesis

The following hypothesis will be tested: Skull-photo superimposition can be done reliably using a computerized technique, including a morphological and landmark based method, to a level of accuracy where no false positive or false negative matches between photographs and skulls occur.

This hypothesis will be rejected should there be more than 1% of false positive or false negative matches between photographs and skulls.

1.4. Importance of the study

This study is an attempt to focus on skull-photo superimposition as carried out in South Africa and to develop the methodology so that it is faster, more efficient and most importantly, has levels of accuracy that are defendable in court. The study will assist in the quantification of reliability of the method, in order to provide a court of law with firm statistics on what the chances are to reliably identify a person from his photograph. The importance of this study is in highlighting and quantifying the reliability of the technique and in showing how it can provide scientists with the statistical knowledge required to present skull-photo superimposition in the legal system.