Chapter 2: Literature review

2.1. Trends in forensic anthropological identification

Forensic anthropology is a branch of physical anthropology that deals with skeletonised human remains in a forensic context. More specifically, "it is the scientific discipline that focuses on the life, the death, and the postlife history of a specific individual, as reflected primarily in their skeletal remains and the physical and forensic context in which they are emplaced" (27). The use of skeletal biology in medico-legal investigations began in the 19th century. Thomas Dwight was dubbed the father of forensic anthropology, along with H. H. Wilder, Jeffries Wyman and Oliver Wendell Holmes. These four men are claimed to have established the field of forensic anthropology as it is known today. Their training was in a mixture of anatomy and zoology. Two of the men were involved in murder trials where they testified, giving evidence in court based on their "qualifications" (28).

It is however thought that George Dorsey (1868 – 1931) was the first fully qualified forensic anthropologist. He acquired his PhD in anthropology in 1896 and was only the second man to receive a PhD qualification in anthropology. Later in his career, Dorsey published on the implications of the human skeleton in medico-legal investigations and was also called as an expert witness (even though he had had no formal osteological training) in the famous Luetgert murder trial. Mr Adolph Luetgert owned a sausage factory and was having marital difficulties with his wife Louisa. His wife disappeared under suspicious circumstances, and only 6 days later did Mr. Luetgert report his wife missing. The Police were suspicious of Mr. Luetgert and his sausage factory- a bad smelling vat was found which supposedly contained potash, fat, tallow

and bone scrapes, to make soap to clean the factory. When investigated further, bone fragments, two rings (one a gold wedding ring with the letters 'L L' engraved on the inside) and a corset stay were found in the vat. After two trials, Mr. Adolph Luetgert was found guilty and sentenced to life in prison. The chain of custody was heavily debated as it was thought that what was found was not handled correctly. Dorsey was the first anthropologist to testify in an American criminal trial, although his testimonies were questionable and controversial, which ultimately resulted in him leaving his academic appointments and his position at a museum (28).

Early in the twentieth century, researchers such as Ales Hrdlička were consulting on forensic cases, although the forensic work was not their primary interest. With the onset of World War II, the need for guidelines on human identification became the task of the anatomists, the most prominent of the time being T. Wingate Todd, a professor at Western Reserve University Medical School, who made significant contributions with skeletal age markers. Wilton Marion Krogman was prominent in the twentieth century in the development of physical anthropology and is also the very first author of a textbook in physical anthropology, published in 1962 (28). There was significant development and expansion of the field in the 1960's, resulting in the formation of a separate section within the American Academy of Forensic Sciences in 1971. The Physical Anthropology section of the academy came about in 1972. In 1977, the American Board of Forensic Anthropology was created under the Physical Anthropology section of the Academy (28, 29).

The investigation of human rights brought a new facet to the field. A violent dictatorship that began in Argentina in 1976 finally came to an end in 1983. During the time that the dictatorship continued in Argentina, many people went missing. Anthropologist Clyde Snow travelled to Argentina to consult and assist in the recovery of the missing or disappeared people. Unmarked graves were being investigated, but with the lack of experience evident, Snow

realised that training was necessary to acquire forensic evidence from these graves. A small group of students was trained by Snow, which ultimately resulted in the formation of the Argentine Forensic Anthropology Team in 1984. This team became involved in the exhumation of graves and the documentation of human rights abuses and they are still continuing their work today (28-30). Similar situations existed in other countries at the same time as Argentina. Countries such as Uraguay, Bolivia, Chile and Boznia- Herzegovina were similarly affected by violent dictatorships resulting in human rights abuses that were investigated after the dictatorships ended uncovering mass graves where individuals needed identification (31). Solla *et al.*(32), has published on cases were individuals went missing during the dictatorial era in Uraguay, were the bodies were finally identified through the use of anthropological analysis including skull-photo superimposition and DNA comparison (31, 32).

In the last decade of the twentieth century, a system of Mortuary Operational Response Teams (DMORTS) was established in the USA, which includes practising forensic anthropologists. The DMORT system falls under the National Disaster Medical System (NDMS). The DMORT teams include specialities such as Anthropologists, Pathologists, Odontologists and X-ray specialists, to name a few. The 10 DMORT teams have been in operation in American National disasters involving flooding, bombing, air disasters and hurricanes. In the aftermath of the World Trade Centre Disaster in 2001, all 10 teams were deployed simultaneously for the first time (28).

Forensic anthropology is also becoming an increasingly popular field of specialisation in South Africa. With the disturbing statistics on violent crime and death in the country, the need for this speciality is becoming ever more important. The discovery of deceased human bodies and skeletonised remains is a frequent occurrence in South Africa, further accentuating the need for such a discipline. Not all cases involve skeletal material. Regularly, cases present where the

body is found and the identity of the individual is never determined. In Gauteng alone, more than 2000 bodies are buried annually where the identity of the individual was never established. This has led to an increase in research in the field of Forensic Anthropology, which includes developing identification standards for South African populations as well as alternative methods of identification. Research in Forensic Anthropology in South Africa has been carried out since the 1940's and includes researchers such as Washburn, DeVilliers, Lundy and Feldsman, Kieser, Loth, Henneberg, Işcan and Steyn (4, 5, 29, 33-35) as well as Bidmos and Asala (36, 37) and Dayal (38) and L'Abbe (39) who is also the first South African diplomat of the American Board of Forensic Anthropologists (ABFA).

Cattaneo (40) explains that while anthropologists primarily deal with human skeletal remains, what is often requested is at the broadest end of the spectrum of the anthropological field, including human physiognomy. The field is developing dramatically and becoming multidisciplinary, with collaborative research with other specialists taking place. The need for the development of standards in facial reconstruction and identification is further highlighted because identification using methods such as skull-photo superimposition are becoming more and more widely used across the world (40). This means that methods used need to be standardised so that they are used consistently around the world.

2.2. The history of craniofacial identification and photographic superimposition

As early as 1883, it was realised that superimposition techniques could lead to identification by carrying out a comparison of the skull with a photograph of the deceased. By studying the skull, a forensic scientist is able to make deductions about the appearance of the face of the deceased (41). Scientists such as Welcker (1883), His (1895), Schaaffhausen (1875, 1883) and von Froriep (1913) played major roles in craniofacial identification. Their studies

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involved analyses of soft tissue thickness, and the relationship that exists between the soft tissue of the face and the skull (41, 42). Therefore the literature on facial reconstruction and skull-photo superimposition often overlap because these techniques are so closely related and very similar.

In the past, portraits, busts and death masks were used in order to establish the identity of an individual. However, with the advent of photography, many new possibilities for identification arose. A French criminologist, Alphonse Bertillon (April 24, 1853 – February 13, 1914), attempted to develop a method which made use of "a system of description and characterisation" (41) which could be used with photographs for identification and which he called "Bertillonage". The Bertillonage method was also later adapted and improved (Stadmuller, 1932 adapting Welckers method to be used with Bertillonage (41)) by enlarging the photographs to be used in the analysis. Attempts were then made to match the photographs with photographs of the skull by using the same focal length at a standard distance, as was used in the Bertillonage method (41, 43).

Bertillon was a French police officer (criminalist) and biometrics researcher who developed a system of description and classification through the use of anthropometry and in so doing, created an identification system based on physical measurements which he took of the head and body. The measurements were used to develop a system of identification that would apply to one person only and would thus be specific to that individual. The system was ultimately found to be inconsistent, because often the measurements were being taken by different police officers who would take their measurements differently. It was also established that measurements taken of individuals with similar phenotypes, such as identical twins, would be identified as a single individual. The principle on which this system of measurements for identification purposes was based was inherently flawed because the methodologies used were subjective and not standardised and therefore other methods of identification were investigated.

When the practice of fingerprinting came into being in 1892, the use of the Bertillon method came to an end and fingerprints were subsequently used for personal identification. Although the Bertillonage method was discredited, Bertillon made other contributions to forensic techniques such as document examination and using galvanoplastics to preserve footprints and ballistics.

There were technical problems with the early methods of skull-photo superimposition- the most important being problems with the photography. When a photograph is available, the skull has to be placed in the same orientation as in the picture. If enlargements to life size had to be made, a point of reference was needed in the photograph to accurately apply this technique. In 1935, Brash and Smith carried out a successful photographic superimposition in the famous Ruxton murder case. Buck Ruxton, a medical practitioner had murdered his wife and her maid and had gone to considerable lengths to prevent the identification of their remains by removing their eyes, teeth and large portions of skin from their faces (44). A photograph of the deceased (Mrs. Ruxton) was available and within the photograph a point of reference could be used in order to successfully enlarge the photograph and carry out the superimposition (7, 41, 44, 45). The superimposition process involved overlaying a negative of the skull over a photograph of Mrs Ruxton in life. The skull and photograph had be scaled to the correct size and orientated so that facial traits were accurately aligned. In the photograph, Mrs. Ruxton wore a diamond tiara which was used as the point of reference for the scaling of the images (42). Outline drawings were made of the skull and face in the photograph and then superimposed.

Another famous case receiving much attention was the Dobkin case which occurred in London in 1942. Skeletonised remains were found in the cellar of a previously bombed Baptist Church. There was a great deal of speculation about the remains possibly being those of a victim of a German blitz raid. However, pathologist Keith Simpson analysed the remains and suggested that the remains could possibly belong to a lady by the name of Rachel Dobkin who had been

reported missing for 15 months. Skull-photo superimposition was carried out using an ante mortem photograph of Rachel Dobkin and very compelling similarities were found. Rachel Dobkin's husband was subsequently found guilty of her murder and the truth was discovered: Mr Dobkin had murdered his wife and placed her remains in the cellar of the bombed church to deceive authorities (42).

There was also an unusual case that occurred in Yugoslavia in 1976 where a scientist was tasked with identifying skeletal remains. The identification of these remains was carried out for religious purposes to positively identify a nun who had been buried in a communal grave. A series of superimpositions were carried out including six skulls from the grave, where the correct skull and remains were selected. Corroborative evidence aided further in the positive identification: the remains showed evidence of lesions on the spine which corresponded to the medical history of the nun (44).

The problem that was noted with the older methods was that if life sized photographs were not used for the superimposition, the result was that one skull may match photographs of different people (3). Gruner and Reinhard cited by Gruner (41) attempted to overcome these problems. They devised a method which used lines, drawings and marking points, taking into account the soft tissue thicknesses, to position a skull in the same orientation as in a photograph. This was done without having to determine the natural size, enlarging or calculating angulations, rotations or tilting. Gruner and Reinhard's method was modified and adapted by Helmer and Gruner (46, 47) to include the use of video superimposition equipment. This method was also modified by Leopold in 1978, which made use of a large format camera and a projection screen between the skull and the camera (41).

The first case study in South Africa on skull-photo superimposition was published in 1986 (48). A skeleton including the skull with mandible was found in a shallow grave along with

a firearm and ammunition. Potential identifying documentation in the form of a South African identity document was found with the remains. Although the identity document was found in close relation to the remains, one cannot assume that it belonged to the individual without proof. The identity document photograph, which was passport sized, contained an unsmiling face of an individual taken slightly from the left (48). The method of superimposition included making a life sized black and white print of the photograph. The area of the eyes in the orbits of the skull were faded or "whited out" so as not to produce a shadow effect in the print. The skull was then photographed at six different angles onto colour transparency film to match angles seen in the photograph. An overhead projector with a zoom lens was then placed at a right angle to the print, which was fixed to a vertical surface, at a distance so that the skull was projected as a life sized image. All six transparencies were projected individually onto the fixed vertical image so that the best match of morphological features between the transparency and image was obtained (48).

The results obtained from this case study indicated that the skeletal remains were those of the individual in the identity document photograph, but the authors did state that the identification was not indisputable, but rather "consistent with, but equivocal" (48).

Modernised techniques were developed and older techniques modified, with the advance of video monitors and video animation compositors. Clyde Snow was the first American scientist to make use of video cameras for photograph superimposition (24, 41, 42, 46, 47). This method included two video cameras that took pictures of the skull and the photograph independently. The photographs were then sent to a video animation compositor or mixer and superimposed over one another on monitors. The intensity of the picture could be varied and strict control of the proportions was achieved (41). As the technique has developed over the years, the technique itself became less important than the main problem of accurately matching a skull to a photograph. It is important to note that superimposition is not about trying to "fit" the skull into a

photograph of an individual's head, but rather an attempt to assess the match of the skull to the face in a photograph.

The introduction of electronic equipment has aided in the simplification of the skull-photo superimposition technique and video superimposition is currently the method used in South Africa (Briers, pers. comm.). This method makes use of a video recording camera(s), a mixing device, equipment for holding the skull and sometimes computer software to help carry out and evaluate the fit of the superimposition (8, 10-12, 18, 19, 22, 25, 26, 44, 46, 49-55). A study done in 1994 by Austin-Smith and Maples tested the reliability of skull-photo superimposition. The authors used three skulls of known identity and compared them to 97 lateral and 98 anterior view photographs. It was found that the chances of having a false positive identification using lateral shots were 9.6% and using anterior shots was 8.5%. However, when using the lateral and anterior shots combined, the chances of a false positive were reduced to 0.6%. This study was done without using anterior dentition to aid with magnification and orientation. An increase in the sample size could have improved the study; however, as more skulls would have been used for comparisons to photographs, this may have resulted in a higher rate of false positives (24).

Bajnóczky and Királyfalvi (22) developed a technique that used a computer-based method to check the results of superimposition. In this study, one skull and two photographs were used for comparison. One photograph was of the person from whom the skull was derived and the other photograph was of an individual whose appearance resembled that of the test cases' photograph appearance. Pairwise comparisons were carried out using points that were marked on the skull, photographs and monitor, for 'afterwards' and 'before' conditions. In principle, the study made use of landmarks on the skull, face and monitor to assess how well the landmarks matched when conducting the superimposition. The materials and methods of this study are very

vague, however, it can be deduced that a mathematical model was utilised as a means of determining the match between the points. Another study carried out by Nickerson *et al.* (45) studied the various methods of superimposition, from Static Photographic Superimposition to Video Camera Superimposition to Digital Photographic Superimposition. The study made use of landmarks as suggested by Chai *et al.* (11) and digitised 3-dimensional scans of skulls to carry out superimpositions. This is similar to the current study, with the use of the landmarks. However, Bajnóczky and Királyfalvi (22) made use of a less complicated method of determining a match between the points they used in their study. They found differences between the "afterwards" and "before" conditions but claimed that the differences could have resulted from errors made with the measurement techniques or from non-identity. Again, this paper is very vague in explanation, but it was recognised that the errors in the measurement techniques are probably due to incorrect positioning and/or inaccurate marking in the "afterwards" and "before" conditions, as the study claimed. They also added that differences could have been due to comparisons of a 2-dimensional shape with a 3-dimensional shape, soft tissue thickness and the photographic process. The authors described this method as reproducible and a as a means of "filtering out" any false positives that may occur. However, they did not describe statistics of how this method has been tested and of the chances that false positives may occur, since the study was carried out as a means of reducing only the false positive rate.

Shahrom *et al.* (25) also made use of computer aided superimposition and tested various techniques of carrying out superimpositions, ranging from cheaper methods to more expensive ones. Facial reconstruction was carried out on the skull of a complete skeleton found in a woodland area. Video superimposition was also carried out when photographs of the suspected individual were used. A cheaper method involving video-transparency superimposition was also carried out. The identity of the victim was confirmed through dental records. They conclude that

while photographic superimposition could have a very useful role in identification purposes, the method should not be overestimated and should be used in conjunction with other corroborative evidence. Shahrom *et al.* (25) furthermore state that this method is useful when no other means of identification are available. Dorion (6) also found that skull-photo superimposition is more helpful in exclusions than with positive identifications.

A second of only two case studies reported in South Africa was published in 2000 (21). Two badly decomposed bodies were found in the Mpumalanga province in December 1996 and January 1997. One of the individuals was found with a South African identity document in close relation to the body and the other body had been tentatively identified by the clothing. Skull-photo superimposition was carried out on both skulls. Both skulls also featured unusual anomalies; one skull featured an under bite, whilst the other had ante mortem tooth loss of both central upper incisors. These features assisted in the identification of both individuals. The issue of the use of dentition is also raised in this paper, however, it is noted that due to generally poor dental record keeping in South Africa, it is very rare that dental records are available to assist in the identification of skeletal remains (5, 21).

Another case in South Africa occurred where skull-photo superimposition was used in a case of suspected murder, in the state against P. Henning in the Pietermaritzburg High Court in 1999. Henning was accused of murdering his farm worker in 1996 and dumping the body in a river. One of Henning's farm labourers had gone missing around the same time Henning was seen to dump 'something' in the river. A skull had washed out downstream from where Henning was believed to have dumped the body and there was great difficulty in identifying the skull as being that of the farm labourer who went missing and was last seen with Henning. Skeletal analysis conducted on the skull (only) by anthropologists at the University of Pretoria's Department of Anatomy established that the skull belonged to a black male adult, approximately

35 years or older- although the age estimation was difficult as only suture closure could be used to establish age. The skull also had a supernumerary upper incisor and a relatively small neurocranium with prematurely fused cranial sutures. All these features can be seen to be factors of individualisation to identify the remains of belonging to a specific individual. Inspector Briers from the South African Police Services carried out skull-photo superimposition and found the skull to match the photograph supplied of the missing farm labourer. In this case the labourer was unfortunately an orphan and therefore comparative DNA evidence could not be used to identify him. The procedure of skull-photo superimposition was used in court along with the supernumery tooth as factors of individualisation to specifically identify the skull as belonging to the missing farm labourer. The identity was accepted by the court and Henning was found guilty (Steyn, pers. comm).

A case study done in India in 2001 aimed to enhance the reliability of the technique. The paper states a previously established 91% rate of positive identification with the use of skull-photo superimposition. They stressed the need for reliability of the technique, because a 91% rate of positive identification reduces confidence in using the technique in court. They suggested a method called "cranio-facial morphanalysis" to correlate the differences in shape of a face (photograph) and skull. The authors introduced an anthroposcopic method of assessing correlations between the face in a photograph and a skull. The study made use of 15 male and 15 female skulls with their corresponding facial photographs. The authors suggested that the use of the cranio-facial morphanalysis together with skull-photo superimposition could improve the reliability of the technique. While the authors claimed that using cranio-facial morphanalysis in conjunction with skull-photo superimposition strengthened the result of the skull-photo superimposition technique, they also stated that the technique cannot claim a definite match or

identification of a skull. They did, however, find the technique helpful in the prevention of mismatching and false identification among their samples (23).

Al-Amad *et al.* (56) described a technique of identification using superimposition of ante mortem and post mortem examination dental records using special features of Adobe Photoshop®. The use of dentition was highlighted due to its survival in harsh conditions, however it is noted that the ante mortem dental records need to be available in order for this technique to be practical. As mentioned above this is problematic in South Africa due to poor or often no dental records existing- nevertheless, the method has value as a supplementary or corroborative means of identification if available (56).

Since the inception of the photo superimposition technique, many different methods of carrying out the procedure have been considered, with major developments having occurred in the last 10 to 15 years. The use of computer equipment has enhanced the technique significantly. Digital photographic superimposition allows the process to be faster too. The questions of the reliability of the technique will always remain. The use of computerised or digital software has improved the skull-photo superimposition technique; however, many laboratories employing the technique still make use of the method using video cameras and animation compositors. The practice of skull-photo superimposition will be discussed further in sections below, along with more detailed assessments of the accuracy of the technique and its applicability in court.

2.3. Skull-photo superimposition: How the technique is carried out in the United States vs. South Africa

Literature reports have focused on how to carry out, as well improve the superimposition technique. This includes the analyses of soft tissue thickness, placement or position of the skull, the size adjustments of the skull in relationship to the facial outline, as well as the relationship of

the anatomical landmarks to the overlying soft tissue. Knowledge of these techniques and a good ante mortem photograph are critical in order to carry out the comparison (24), and will be discussed in detail below.

The practice of skull-photo superimposition in the United States and South Africa is very similar. The notable differences in the techniques are that in the United States tissue depth markers are employed to assist with skin tissue thickness and a computer is used to capture the final image. The equipment includes a video camera(s), a video mixer, a TV monitor and a video cassette recorder. In the United States, two video cameras are used to film the skull and photograph independently and then the computer captures the superimposed image. In South Africa, one video camera is used to film the skull and photograph independently, with the help of the mixing device to store the images separately to be used for the superimposition (21, 26).

Some time was spent at Michigan State University in East Lansing in the US by the investigator. A short internship was undertaken to learn the methods of the skull-photo superimposition procedure as it is carried out there. Their superimposition process starts with placing skin tissue thickness markers on the skull. They then make use of a "dynamic orientation process" to align the skull correctly with the photograph. This involves placing the ante mortem photograph under one video camera so that the image fills the screen of the monitor. The skull with tissue depth markers is placed under the second camera. Using the mixing device and the TV monitor, the skull image is sized so that it is the same size as the image of the face. When the skull and photograph are correctly aligned and sized, the cranio-facial proportions of the skull and photograph are assessed. This is carried out by adjusting the skull manually so that the skeletal landmarks of the skull match up with landmarks on the face in the photograph. Ideally, the best method to align the skull and photograph is to align them at the landmark porion. Porion on the skull is established by placing ear-buds into the external auditory meati of the skull, which

would match up with the left and right tragi of the ears. Next, the Whitnall's tubercles are aligned with the left and right ectocanthion points on the face. The Whitnall tubercle is a bony eminence on the zygomatic bone located on the lateral margin of the left and right orbits (Sauer, pers. comm.) (26).

The above steps are imperative to establish the correction angles of inclination and declination, so as to match the angle in the photograph. Following this, the subnasal point of the skull is aligned with the subnasal point of the face in the photograph. The next step is to align gnathion on the skull, with the identical point on the face in the photograph. This "dynamic orientation process" is described to be very challenging and time consuming. Much time is spent making sure that the adjustments for size and alignment between the two images are done accurately, so that the process is carried out correctly.

If landmarks from the skull and photograph are not aligning, then it could be an indication that the skull and photograph are not of the same individual. In the final step of the skull superimposition process an overall evaluation of the morphological features of the face and skull is made. This is done by following the Austin-Smith and Maples (24) list of morphological requirements to establish a match as a guideline. Their guidelines stipulate that 12 morphological features in the frontal view of the skull and photograph should correlate in the superimposition process. It is noted that some of the 12 features may not be seen in the photograph due to the presence of hair. These features are summarised in Tables 2.1 and 2.2 below. Once the assessment between photograph and skull is carried out, considering all morphological features and craniometric landmarks, conclusions regarding the inclusion or exclusion of the skull and photograph are made (26).

Due to the inconsistencies and inaccuracies noted in the literature (6, 15, 22-26), practitioners in the United States have adopted a policy of using skull-photo superimposition

only for exclusion in court. Therefore the identification of skeletal remains is made through the use of dental identification as well as skull-photo superimposition for exclusion purposes i.e. trying to exclude a skull as belonging to a photograph (26).

In South Africa the superimposition process is commenced by filming the ante mortem photograph. This image is then stored in the mixing device for later use. The skull is placed on a skull stand with sticks placed into the external auditory meati. The skull is then filmed with the video camera. With the use of the mixing device, the photograph image is displayed onto the TV monitor and outline drawings of morphological features of the face are made with a non-permanent marker.

Table 2.1. Table of requirements of a lateral consistent fit between skull and face (taken from Austin-Smith and Maples (24))

	Lateral view requirement

1.	The vault of the skull and the head height must be similar.
2.	The glabellar outline of both the bone and the soft tissue must have a similar slope although the line of the face does not always follow the line of the skull exactly. There must be slight differences in the soft tissue thicknesses that do not relate to nuances in the contour of the bone.
3.	The lateral angle of the eye lies within the bony lateral wall of the orbit.
4.	The glabella, nasal bridge, nasal bone area is perhaps the most distinctive. The prominence of the glabella and the depth of the nasal bridge are closely approximated by the soft tissue covering this area. The nasal bones fall within the structure of the nose and the imaginary continued line, composed of lateral nasal cartilages in life, will conform to the shape of the nose except in cases of notably deformity.
5.	The outline of the frontal process of the zygomatic bones can normally be seen in the flesh of the face. The skeletal process can be aligned with the process seen in the face.
6.	The outline of the zygomatic arch can be seen and aligned in those individuals with minimal soft tissue thickness.
7.	The anterior nasal spine lies posterior to the base of the nose near the most posterior portion of the lateral septal cartilage.
8.	The porion aligns just posterior to the tragus, slightly inferior to the crus of the helix.
9.	The prosthion lies posterior to the anterior edge of the upper lip.
10.	The pogonion lies posterior to the indentation observable in the chin where the orbicularis oris muscle crosses the mentalis muscle.
11.	The mental protuberance of the mandible lies posterior to the point of the chin. The shape of the bone (pointed or rounded) corresponds to the shape of the chin.
12.	The occipital curve lies within the outline of the back of the head. The area is usually covered with hair and exact location may be difficult to judge.

Using the mixing device, the image of the skull and photograph are displayed on the TV monitor simultaneously. The skull is aligned and sized with the photograph using the sticks in the external auditory meati to match the tragi of the ears.

Table 2.2. Table of requirements of a frontal consistent fit between skull and face (taken from Austin-Smith and Maples (24))

	Frontal view requirement

1.	The length of the skull from bregma to menton fits within the face. Bregma is usually covered with hair.
2.	The width of the cranium fills the forehead area of the face.
3.	The temporal line can sometimes be distinguished on the photograph. If so, the line of the skull corresponds to the line seen on the face.
4.	The eyebrow generally follows the upper edge of the orbit over the medial two-thirds. At the lateral superior one-third of the orbit the eyebrow continues horizontally as the orbital rim begins to curve inferiorly.
5.	The orbits completely encase the eye including the medial and lateral folds. The point of attachment of the medial and lateral palpebral ligaments can usually be found on the skull. These areas align with the folds of the eye.
6.	The lacrimal groove can sometimes be distinguished on the photograph. If so, the groove observable on the bones aligns with the groove seen on the face.
7.	The breadth of the nasal bridge on the cranium and surrounding soft tissue is similar. In the skull, the bridge extends from one orbital opening to the other. In the face, the bridge spreads between the medial palpebral ligament attachments.
8.	The external auditory meatus opening lies medial to the tragus of the ear. The best way to judge this area is to place a projecting marker into the ear canal. On superimposition, the marker will appear to exit the ear behind the tragus.
9.	The length and width of the nasal aperture falls outside the borders of the nose.
10.	The anterior nasal spine lies superior to the inferior boarder of the medial crus of the nose. With advanced age the crus of the nose begins to sag and the anterior nasal spine is located further superiorly.
11.	The oblique line of the mandible (between the bucinator and the masseter muscle) is sometimes visible in the face. The line of the mandible corresponds to the line of the face.
12.	The curve of the mandible is similar to that of the facial jaw. At no point does the bone appear to project from the flesh. Rounded, pointed, or notched chins will be evident in the mandible.

Once the skull and photograph are correctly aligned and sized, the cranio-facial proportions of the skull and photograph are assessed. This is carried out by adjusting the skull manually so that the skeletal landmarks of the skull match up with landmarks on the face in the photograph. The task of adjusting the skull to the image in the photograph is challenging and tedious, and can take up to several hours.

The line drawings made on the TV monitor assist with the matching process. The line drawings can show morphological features on the monitor when the image in the photograph is not clear because of the mixing of the images of the photograph and skull. A morphological comparison between the skull and the face in the photograph is then carried out to assess whether the skull matches the face in the photograph and thus a decision on whether the skull matches the photograph is made. Aspects of the superimposition technique explained above have been published (21), however elements of the above description of the skull-photo superimposition technique result from personal observations during sessions spent at the laboratory observing how the technique is carried out.

Although there are inconsistencies noted in the literature (6, 15, 22-26), South Africa has adopted an inclusion policy for the use of skull-photo superimposition in court. Therefore the identification of skeletal remains can be made through the use of skull-photo superimposition for inclusion purposes i.e. establishing whether the skull belongs to the face in the photograph or not (21, 48).

2.4. The accuracy of skull-photo superimposition

Since the establishment of the photographic superimposition technique, various scientists have examined the procedure in order to improve and assess the accuracy of the results (8, 10-12, 19, 24). Many authors believe the inclusion of teeth improves the accuracy of the result obtained, as matching a photograph (where teeth are visible) to a skull (where teeth are still in their sockets) is far easier and more accurate. Matching the dentition from a photograph to the dentition on a skull, aids in the magnification process and confirms a definite match or elimination depending on how the other anatomical landmarks fit (7). If dentition is available, an attempt is made to match them to ante mortem dental records. However, in many cases no

dentition is available and photographic superimposition is carried out using other anatomical landmarks to determine whether there is a match (7, 10, 24).

Since the development of the technique of photographic superimposition, the accuracy of the technique has not been stringently tested. Most of the initial studies around photographic superimposition focused on the development of better techniques and equipment with which to carry it out (8, 10-12, 18, 19, 22, 24, 25, 48, 49, 51-54, 57). Few studies have been carried out that tested the accuracy and scientific validity of the technique. One of the first studies was carried out on an American population in the early 1990's by Austin-Smith and Maples (24) as discussed above, which found that the chances of having a false positive identification using lateral shots were 9.6% and using anterior shots, 8.5%. However, when using the lateral and anterior shots combined, the chances of a false positive were reduced to 0.6%.

Aulsebrook *et al.* (58), around the same time as Austin-Smith and Maples (24), conducted a survey on skull-photo superimposition and facial reconstruction. They discussed the validity of the superimposition technique citing authors Cocks and Brown (44) who were trying to achieve a method of objectively "quantifying a comparison" (58). The idea of Cocks and Brown was to make use of points or measurements that could be used on the skull as well as a face or photograph. However, another accuracy problem is encountered in this method, because the repeatability of the points or measurements is difficult and in turn could affect whether false positives or false negatives are identified (58). Grüner (41) and Aulsebrook *et al.* (58) additionally did studies to calculate the distinctiveness of the human skull and they concluded that skulls were as individual and distinct to a particular person as a finger print. Aulsebrook *et al.* (58) agree with Işcan's (29) opinion that skull-photo superimposition should be used in addition to other identification techniques as corroborative evidence. They also cite De Vore's (1977) work which claims that skull-photo superimposition should be used for exclusion

purposes rather than inclusion purposes. Both Dorion (6) and Shahrom *et al.* (25) believe that while photographic superimposition may enhance the process of identification, it should be used in conjunction with other evidence, as misidentifications have been reported in the past. The suggestion is to use the technique along with definitive corroborative evidence such as dental records (where available) or other forms of evidence, such as a biological profile that matches the remains in question.

Jayaprakash *et al.* (23) also elucidate the use of skull-photo superimposition as an identification tool, and mention a previously published 91% accuracy rate. They declare that this technique is not "wholly reliable" (p. 121), and suggested a new technique called "cranio-facial morphanalysis", as described above. This was also found to be not completely reliable with the authors using the statement that "the skull could very well have belonged to the person seen in the photograph" (p. 136). The legal implications of such a statement will be further discussed below.

Although court systems have accepted skull-photo superimposition as an identification tool all over the world, not all court systems use the tool in the same manner. Whilst some use the technique to include an individual (i.e. to identify him/her) other courts use the technique to exclude individuals. In both South African case studies mentioned previously, the identity of the individual was suspected, and corroborative evidence was available. In the earlier study the individual was found with a South African identity document along with other evidence in the shallow grave. The identity document photograph was used to determine his identity. In the second study published, two individuals were found in separate locations. One individual was identified tentatively by his clothing and a photograph was obtained, and the other individual had a South African identity document found in close relation to the remains. In all three cases the technique was used to identify the remains (21, 48).

Fenton *et al.* (26) were tasked with identifying the comingled remains and personal effects of some hikers which were discovered in remote area of desert near a southern Arizona town. Through the combined efforts of authorities in the United States and Mexico, it was established that the remains in question were those of five individuals of Mexican origin. The authors described their technique using a "dynamic orientation process" to correctly align and size the skull and photograph for the superimposition process. The idea of carrying out this process is to exclude a skull from possibly matching the photograph. If the skull cannot be excluded, then it suggests that it represents the individual in the photograph. It is noted that the technique is not used in the same manner around the world. The only validity studies that have been done were in the United States, India and also China (23, 24, 53). However, none have been conducted in South Africa, even though the technique is frequently used.

2.4.1. The role of photography in skull-photo superimposition and identification

Redsicker (59) explains that in the field of forensic photography, the photographer's work is scrutinized not for its artistic content but rather the accuracy with which it depicts the topic of interest. The depth of field of a photograph becomes important in crime photography where crime scenes have to be photographed. The depth of field is defined as the area which appears in focus from the foreground to the background. For an overall series of crime scene photographs, a greater depth of field is needed as opposed to a situation where specific detail is needed from a e.g. a shoe impression or blood spatter mark (59). The depth of field becomes very important if being used for skull-photo superimposition. Variation in the technique of the photography i.e. the distance from the camera or the angle of the camera can produce variations which may not be normally observable between two identical images.

Eliášová and Krsek (60) describe distortions that can occur with photographs and how this may influence the accuracy of skull-photo superimposition. The process of superimposition makes use of a 2-dimensional image which is superimposed onto a 3-dimensional object. The image has many factors that contribute to the distortions, such as the conditions whilst the photograph is being taken as well as intrinsic and extrinsic parameters of the camera (60). Although the authors claim that that they are able to explain the distortions through the use of a mathematical model, one must question whether the person carrying out the superimposition will be able to put the model to use, as deeper understanding of photography and mathematics is required for this. This further highlights the problems when making use of skull-photo superimposition as a sole tool for the identification of skeletal remains, since misidentifications could occur based purely on a photograph that contains these distortions.

2.4.2. The use of anatomical/ craniofacial landmarks in skull-photo superimposition

Anthroposcopy is a method of assessing the body's build by visual inspection. Visual assessment is a very old method which is still being used in medicine today. It is not very consistent due to the subjective nature of the method. Anthropometry involves the measurement of elements of the human body. These are more objective and more consistent and thus more reliable. Anatomical / craniometric landmarks have been indentified on the human face / skull for the purposes of taking anthropometric measurements. Anthroposcopy is used to observe and identify physical characteristics such as landmarks on the face of an individual (61, 62). Both anthropometry and anthroposcopy play roles in the technique of skull-photo superimposition.

Anatomical landmarks can play an important role in the identification of an individual when being used in photography and camera surveillance. Modern techniques of studying the face for the purposes of identification in the forensic context include techniques that use metric

analyses (measurement), morphological analyses (shape of the features) and superimposition, which this study is testing. So these techniques can be used to compare two photographs, a face and a photograph as well as a skull and a photograph (63).

Various studies have aided the process of identification through the use of anatomical / craniofacial landmarks and the measurements that can be made using these landmarks- the measurements and (or) proportions that are obtained from the photograph or camera evidence can be used to successfully identify the perpetrators of crime. This form of identification, also termed 'facial image identification', can be done morphologically, anthropometrically and also through superimposition (14). The morphological method uses proportions and features of the face such as the eyes, eyebrows, eyes, nose, ears and lips with classification systems that have been published. An anthropometric analysis is based on indices which have been calculated from facial dimensions, but also include ear or nose shape and hairstyle etc. Superimposition is suggested as a method of comparing the two images of facial dimensions in an attempt to carry out a facial comparison. Examples of this anthropometric analysis are used in the application of access control systems as well as the well known facial identification system "Identikits". Anthropometric analysis and "Identikits" are especially useful with the large amount of identity document fraud that occurs in South Africa and elsewhere (53, 63).

The use of anatomical landmarks in skull-photo superimposition was introduced to be employed in conjunction with the superimposition technique, in order to rule out the possibility of false positives or false negatives. This has been one of many suggestions to better the accuracy of the technique (15, 24). This is of particular importance to this current study, as the literature discussed highlights the problems with regard to angles in photographs, distortions in photographs / images and poor quality photographs. It stresses the importance of developing a technique with which to identify individuals from photographs that is accurate and repeatable. As

mentioned by Roelofse *et al.* (63), the use of anatomical landmarks is important in the identification of individuals from photographs, and this also holds true for superimposition.

2.4.3. Forensic sciences, evidence and the legal system

Scientific evidence is claimed to be "fact or opinion evidence that purports to draw on specialized knowledge of a science or relies on scientific principles for its value" (64). Expert testimony that is given in court is based on technical, scientific and / or other specialized knowledge which has been acquired by an individual who is qualified to testify based on the experience they have gained in their daily duties. An expert is someone recognized by the legal system that may be called upon to describe the evidence as well as its significance to the case being presented. Rules have been formulated in the court systems that establish who is qualified as an expert witness, what aspects of the case they may provide testimony on and whether this testimony is in fact reliable (64).

It is important to note that a "lay" witness may only provide evidence on observed facts, and may not offer any opinions regarding those facts. A "lay" person is someone who has demonstrated an aptitude to perceive, recall and recount their own knowledge truthfully. An expert witness is defined as "[a] person who, through education or experience, has developed skills or knowledge in a particular subject, so that he or she may form an opinion that will assist the fact finder" (64). Therefore an expert witness has experience beyond the general understanding of the public. The expert testimony has the role of assisting the jury so that factual conclusions regarding evidence can be made.

There are also rules regarding the admissibility of the evidence that may be provided in the legal system. The concern with the evidence being offered in court is that the testimony of an expert witness has the ability to mislead the jury. Therefore the court has to ensure that the expert

testimony is "based on facts or data, is the product of reliable principles or methods, and that the experts' conclusions are reliable and relevant" (64-66).

There are two major approaches to expert opinion in court; these are the *Frye* approach and the *Daubert* approach. Each of these approaches applies different rules to the presentation of scientific evidence in court. The *Frye* approach was the original method whereby scientific evidence was reviewed. The *Frye* standard requires that the scientific principle used had "gained general acceptance in the specific field" before the principle could be used for expert testimony. This rule creates great difficulties when applied to the use of "new" scientific evidence, due to the fact that evidence based on a science that is developing or a science that is very novel may not be considered as "generally accepted". While this standard is not used in many places anymore, it is still used in some jurisdictions in the US (64).

The *Daubert* standard is originally stated (in its entirety) as follows: "If scientific, technical, or other specialized knowledge will assist the trier of fact to understand the evidence or determine a fact in issue, a witness qualified as an expert by knowledge, skill, experience, training, or education, may testify thereto in the form of an opinion or otherwise" (27, 66). The standard is based on a two part test namely reliability and relevance that must be employed, when the evaluation of scientific evidence is carried out. The test also includes questions on whether the scientific theory had been subjected to testing, to peer review and to publication, whether the theory has a potential rate of error and whether the technique is generally accepted. The major difference between the *Frye* and *Daubert* theories is that the *Frye* standard is only concerned with the admissibility of scientific evidence in court. The *Daubert* standard, however, requires participation from the court in evaluating the relevance of the scientific theory to the facts being presented in a case (64, 66).

The *Daubert* criteria were introduced into the courtroom in order to try and eliminate "pseudo-science" type evidence, which is evidence presented by an expert witness, based purely on the expert witness' anecdotal or personal experience in the field and not on the results of tried and tested techniques or validation studies (Steyn, pers. comm.). This has changed the field of Forensic Anthropology greatly, not only in terms of what research is carried out, but also how it is carried out.

The South African legal system has its roots in Roman Dutch Law which has been developed over the years into the legal system as we know it today. Statutory laws on the other hand, are developed by the South African legislative body and are passed by Parliament. These Statutory Laws include the *Births and Deaths Registration Act, 1992 (Act no. 51 of 1992)*(67) and the *Inquests Act, 1959 (Act no. 58 of 1959)* (68)*,* which respectively provide for the registration of births and deaths of individuals, as well as investigations into the circumstances and causes of unnatural deaths (69). The *Criminal Procedure Act, 1977 (Act no. 51 of 1977)* (70) is another Statutory Law which provides for the processes in criminal proceedings relating to the prosecution of crimes in South Africa.

Common Law includes Roman-Dutch Law and is developed and built up from previous court cases and the decisions made in those court cases, i.e. legal precedent. In this manner, court proceedings are based on legal rules and principles developed from prior Higher court decisions also known as Case Law. In South Africa, murder, culpable homicide and theft for example, are Common Law offences in which Statutory Laws are used. A Common Law offence such as murder will be investigated by the police, following which evidence will be presented at a criminal trial led by a state prosecutor, for the purposes of verdicts and sentencing. Civil trials involve the infringement of an individual's rights for which that individual seeks redress, where the State plays no role (69).

In South Africa, the legislative aspects of the performance of medico-legal autopsies are governed primarily by the *Inquests Act, 1959 (Act no. 58 of 1959*) (68), where such autopsies and ancillary investigations then form part of the police's investigative processes into unnatural deaths. Medico-legal autopsy and ancillary forensic evidence may then be presented at Inquest courts and / or at criminal trials, for the purposes of conveying the medical and forensic scientific evidentiary findings relating to circumstances, causes and mechanisms of death (69). The *National Health Act, 2003 (Act No. 61 of 2003) "Regulations Regarding the Rendering of Forensic Pathology Service"* (71, 72) define clearly who may perform and / or contribute to a medico-legal post mortem examination in sections 16 and 17, under the heading: *"Practitioners authorised to conduct post mortem examination"* viz. *"16. A post mortem examination must only be performed by an authorised person who has been appointed by the Head of Department for this purpose."* Furthermore, it states in section 17 that *"17. An authorised person may consult with other qualified professionals and request such professionals to participate in the post mortem examination and contribute to the further examination of such a body."* These Regulations (72) also define who this *"authorised person"* is, namely that *"an authorised person means a medical practitioner registered as a forensic pathologist or forensic medical officer in terms of the Health Professions Act, 1974 (Act No. 56 of 1974)* (73)*, to perform post mortem examinations or autopsies on a body and appointed in terms of regulation 16 of these regulations"* (as above). In terms of sections 19 and 20 of these Regulations, *"19. ..... an authorised person may submit for examination, or cause to be submitted for examination, any tissue, fluid, object, or thing related to a body, to an authorised institution, for purposes of establishing the cause and circumstance of a death of a person or for furthering the administration of the processes and administration of justice."* and *" 20. An authorised person is the only person who has the authority to decide to dissect a body, remove or cause to be*

removed, any part, organ or contents of a body for a special investigation". The implications of these extracted sections are clear, in that even when skeletonised remains are to be examined, such cases first have to be admitted to the relevant regional Forensic Pathology Service Mortuary, before being referred by an "authorised" medical practitioner to e.g. an (Forensic) Anthropology Division, for further anthropological investigations as may be required. These usually include as the top and most frequent priority, to determine the identity of the deceased. It must also be noted that these Regulations also define what is to be understood under "unnatural deaths" namely: *"For the purposes of the medico-legal investigation of death, the following shall be deemed to be deaths due to unnatural causes-*

(a) any death due to physical or chemical influence, direct or indirect, or related complications;

(b) any death, including those deaths which would normally be considered to be a death due to natural causes, which in the opinion of a medical practitioner, has been the result of an act of commission or omission which may be criminal in nature: or

(c) where the death is sudden and unexpected, or unexplained, or where the cause of death is not apparent".

Skeletonised remains frequently belong to the categories stipulated in (a) and (c) of these definitions and as thus, need to be fully investigated from a medico-legal perspective, to establish in as far is possible, circumstance and cause of death, together with the identity of the remains.

The scope of practice for forensic pathologists in South Africa is further outlined in the *"National Code of Guidelines for Forensic Pathology Practice in South Africa"* (74), as authored and published by the "National Forensic Pathology Service Committee", referred to in Section 37 of the *Regulations Regarding the Rendering of Forensic Pathology Service of the National Health Act, 2003 (Act no. 61 of 2003)* (71, 72, 74). According to the *"National Code of*

Guidelines for Forensic Pathology Practice in South Africa", Forensic Pathology Service has as its primary objective *"the rendering of a medico-legal investigation of death service that serves the judicial process."* In addition, it states that *"it is essential that standardised and uniform protocols and procedures are followed nationally, rendering objective, impartial and scientifically accurate results."* If these standardised processes are not adhered to, doubt may be cast on the reliability and relevance (in accordance with the *Daubert* criteria described above) of the forensic medical or scientific evidence presented to the courts (Vellema, pers. comm.).

The term "forensic evidence" may be used to describe the manner in which information is presented to the courts and includes verbal evidence (e.g. witness testimony), documentary evidence (e.g. autopsy reports) and physical / tangible evidence (e.g. objects like bullets) (75). In South Africa, documentary forensic evidence can be submitted to the courts by means of an Affidavit, which is a written statement wherein the person swears under oath to the truth contained in the statement; or a Solemn Declaration which is similar to the Affidavit, but no oath is taken. The investigation into the cause of death involves the medical practitioner who may be called upon to give evidence in court in 4 ways: 1) as a defendant in civil or criminal action; 2) as a witness of fact e.g. armed robbery; 3) as a professional witness e.g. treatment of a case in casualty; and 4) as an expert witness who is seen in the eyes of the law as an individual who, through education, training and experience, possesses knowledge beyond that of a lay person. In a courtroom setting, expert witnesses are called upon to ensure that complex scientific principles are understood by lay persons, but they are also frequently expected to give "opinion evidence" based on experiential conclusions drawn from factual findings (69, 75). The practice of how scientific evidence is presented in court in South Africa differs from the *Daubert* and *Frye* standards, but does include aspects from both standards. In Chapter 24 of the *Criminal Procedure Act, 1977 (Act no. 51 of 1977)* (70), aspects pertaining to the presentation of evidence

in court are covered, but none specifically pertaining to scientific requirements for "newer" e.g. forensic sciences-related expert witness testimony. This illustrates an area in the legal system in South Africa where more consideration is needed.

The standard used for the admissibility of evidence in court has serious implications for the use of skull-photo superimposition. The expert testimony on the technique of skull-photo superimposition would not be accepted in court if the *Frye* standard were used for the admissibility of evidence, because, as stated before, the *Frye* standard requires that the scientific principle is generally accepted in the field. Although skull-photo superimposition may be accepted as a means of identification, the methods and the accuracy of the technique are still developing and therefore could not be used as admissible evidence for expert testimony, as it is not a "generally accepted "and agreed upon method in the scientific community. The *Daubert* standards are generally employed around the US for the admissibility of evidence in court. This is important with regard to the skull-photo superimposition technique since the technique, as mentioned previously, is not used consistently around the world. In South Africa, skull-photo superimposition is currently accepted by the legal system for the identification of skeletal remains. Therefore, consideration is needed in the South African setting to develop more specific legislative criteria for the minimum standards of scientific testing of techniques, so that they comply with the scientific objectives of relevance, repeatability, accuracy and reliability.

Skull-photo superimposition is a generally accepted method for the identification of skeletal remains even though the reliability of the technique is still questioned by some scientists and the technique is used differently around the world. It is very important to note that the technique is constantly being developed further, to achieve improved methods that are more valid and reliable (26, 64, 66, 76). Results from the practice of skull-photo superimposition consistently show that it is a valuable technique for the identification of skeletal remains;

however results presented in the literature consistently indicate that the technique should be used for the purposes of exclusion, rather than as a primary identification method.

2.4.4. Skull-photo superimposition for exclusion or inclusion purposes

Exclusion or the "failure to exclude" is presented as being a "safer" means with which to use skull-photo superimposition for identification purposes. Exclusion is a means of identifying skeletal remains through the use of skull-photo superimposition, by excluding any other skull/ set of remains as belonging to the individual in the photograph. The "failure to exclude" method is better used in closed (mass) fatality cases which means there are a known number of remains, the identities of the individuals are known, and all that is required is to match the skeletal remains to a specific missing person. By not excluding skeletal remains as belonging to a specific individual, it suggests that the remains belong to that individual, and therefore a positive identification can be made (26).

Fenton *et al.* (26) clarify their approach as being similar to other literature where skull-photo superimposition seldom yields a positive identification. By beginning their superimposition with the assumption that the skull and photograph belong to the same individual, Fenton *et al.*, (26) are able to reject their initial assumption when differences in proportions or anthropometric landmarks are discerned. If, however, very few substantial differences can be observed, then they conclude that the skull and face in the photograph may indicate the same individual.

As already noted, this differs to the technique as practised in South Africa. The manner in which the legal system operates is also different and more lenient in South Africa, where it pertains to minimum scientific standards for the presentation and acceptability of scientific evidence. It would seem that stricter and clearly defined legislative parameters for the

presentation of scientific evidence by expert witnesses are needed in South Africa. *Daubert* requires that scientific theories are repeatable and have validation. Currently, this cannot be said for skull-photo superimposition in South Africa. The questions regarding the accuracy of the technique and the differences in the methodologies of the skull-photo superimposition techniques around the world encouraged the present study.