

CRANIOFACIAL IDENTIFICATION BY COMPUTER-MEDIATED SUPERIMPOSITION

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ABSTRACT

Mass disasters are associated with a large number of fatalities, with victims being visually unidentifiable in most cases. Dental identification, although being an important and valuable identification method, is subject to the availability and quality of antemortem and postmortem dental records. This paper presents a simple-to-use method of human identification using an antemortem photograph showing anterior teeth with superimposition onto a postmortem image using specific features of Adobe® Photoshop®.* We present cases and discuss the benefits and difficulties of this method.

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Key words: superimposition, identification, Adobe Photoshop, victim; tsunami, disaster

INTRODUCTION

The identity of the dead is important for well-appreciated reasons. In most cases a family member or acquaintance is able to identify the deceased visually, but this method is sometimes inapplicable if the deceased has lost facial features. Cases of incineration, decomposition or skeletalization necessitate the use of a scientific identification method. The use of dental characteristics is an identification method that has significant utility due to its accuracy, cost and time effectiveness by comparison with other identification methods. Postmortem dental material can sustain harsh circumstances, such as fire and petrification, and still retain utility as an identification method. However the greatest problem is often the lack of sufficiently detailed antemortem records to allow for a meaningful comparison. If these limitations occur other methods of identification need to be approached and photographic superimposition is one such method.

In this paper, we present cases which were identified using Adobe® Photoshop® version 7*. We discuss the technique with emphasis on its value as a supplementary identification method in mass disasters where forensic odontologists might be challenged with victims whose antemortem dental records are inadequate or are absent.

Case one

A middle aged male died in the Indian Ocean tsunami disaster. His body was decomposed and was visually unidentifiable at the time of postmortem examination. Dental examination revealed extensive restorative work and missing upper lateral incisor teeth. More than seven months after his death, the dental reconciliation team was able to find a possible antemortem dental record which showed missing upper lateral incisor teeth and only one restoration on the upper right second molar. Both features were consistent with the postmortem findings, but were considered insufficient for identification to be established.

Considering that the anomaly of missing upper lateral incisors is uncommon, an attempt to perform superimposition was undertaken. Several antemortem portraits showing anterior teeth were obtained from the next of kin. One of these showed upper anterior teeth in reasonable resolution. The antemortem photograph was scanned at 600 dpi and a series of postmortem photographs was taken from different angles by using a three-step ladder (five horizontal positions, approximately thirty centimeters apart, and three vertical positions from each horizontal position, approximately fifteen centimeters apart) with a digital single-lens reflex camera.** Postmortem images with the closest viewing angle to that of the antemortem portrait were selected; then superimposition, using Adobe® Photoshop®, was performed and successfully resulted in a consistent dental and craniofacial match (Fig.1). DNA analysis

*Adobe Systems Incorporated, California USA 2002

**Canon EOS 300D, Canon Inc. Tokyo, Japan

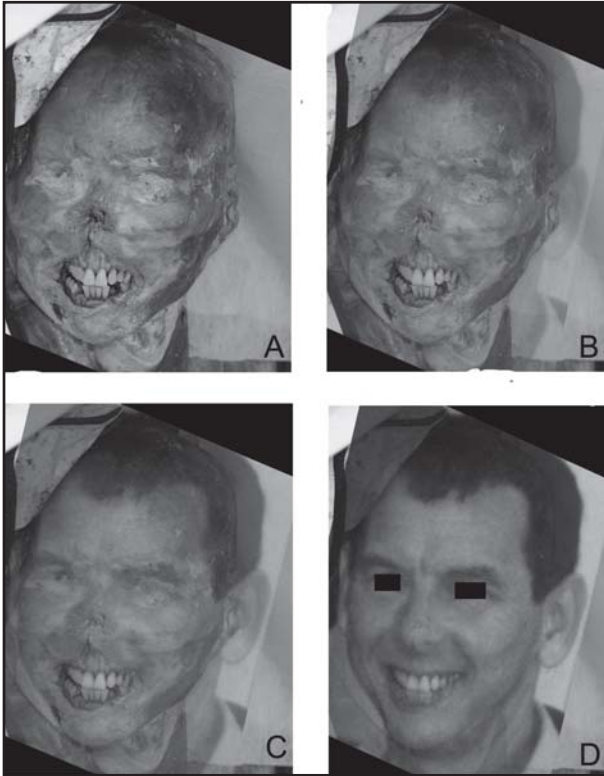


Fig.1: Case one. A through D show superimposition of portrait onto postmortem remains using the anterior teeth as a guide. Opacities were for: A 1%, B 25%, C 50% and D 90%

was performed later and confirmed the positive identity.

Case two

A child, aged approximately twelve years, who was a victim of the Indian Ocean tsunami disaster was skeletalized at the time of postmortem examination. The child had fissure sealants on all first molars and had fixed orthodontic appliances on the upper and lower teeth. Antemortem records of children of approximately the same age and with fixed orthodontic appliances were collected (forty records of both genders) and each case was carefully examined. One of these antemortem records contained a recent model of the upper and lower teeth that showed irregular incisal edges of the upper two central incisor teeth. A series of photographs was taken of this model from different angles of an imaginary grid (using the same camera as in case one), to try to reproduce the camera angle at which the postmortem picture was taken. When a satisfactory angle was reached, superimposition

was performed using Adobe® Photoshop® which resulted in a compelling match (Fig. 2). No further identification methods were considered necessary.

Case three

A tooth was recovered from a suspected crime scene and was the only human remains found. The tooth was identified as a human lower right lateral incisor. The tooth showed evidence of periodontal disease with traces of subgingival calculus, oblique attrition of the incisal edge and a fractured root apex. The antemortem record consisted of a written dental treatment card and an orthopantomogram (OPG) of the suspected victim taken seven years previously (Fig.3A). It showed the lower right lateral incisor tooth with similar pattern of wear. In order to obtain a comparable image, we converted the tooth into an OPG image by fitting it in its corresponding position in a dentate acrylic skull replica (Fig. 3D and E). The radiology service where the antemortem OPG was performed was located and its staff confirmed that they have been operating the same OPG machine for more than seven years. The tooth in the acrylic skull was radiographed using that same machine which produced a comparable image (Fig.3B). Both radiographs were scanned at 600 dpi and superimposition, using Adobe® Photoshop®, was performed. There was a compelling match between the outline, including the pattern of attrition of the right lower lateral incisor tooth of both images (Fig. 3C) which proposed a positive identification.

Technique

Antemortem and postmortem images are opened within Adobe® Photoshop® and the areas of interest cropped using the **crop tool**. One image can then be either “dragged and dropped” or “copied and pasted” onto the other image which will automatically become the background layer resulting in an overlaid image. One layer can be expanded or shrunk against the other in order to obtain a one-to-one relationship. This can be performed using the **free transform** tool in the edit menu or simply by clicking **Ctrl-T**. This tool will create a rectangle around the highlighted layer. Changing the size of this rectangle can be undertaken by “dragging” one of its corners. Holding the **shift** button while resizing the image is necessary to prevent distortion and will keep changes to the x and y axes consistent. This tool also gives the operator the advantage of rotating the highlighted image in the x and y axes.

The resizing and rotation of the overlaid image can be performed only if one layer is semi-transparent so that the operator can see the outline of the

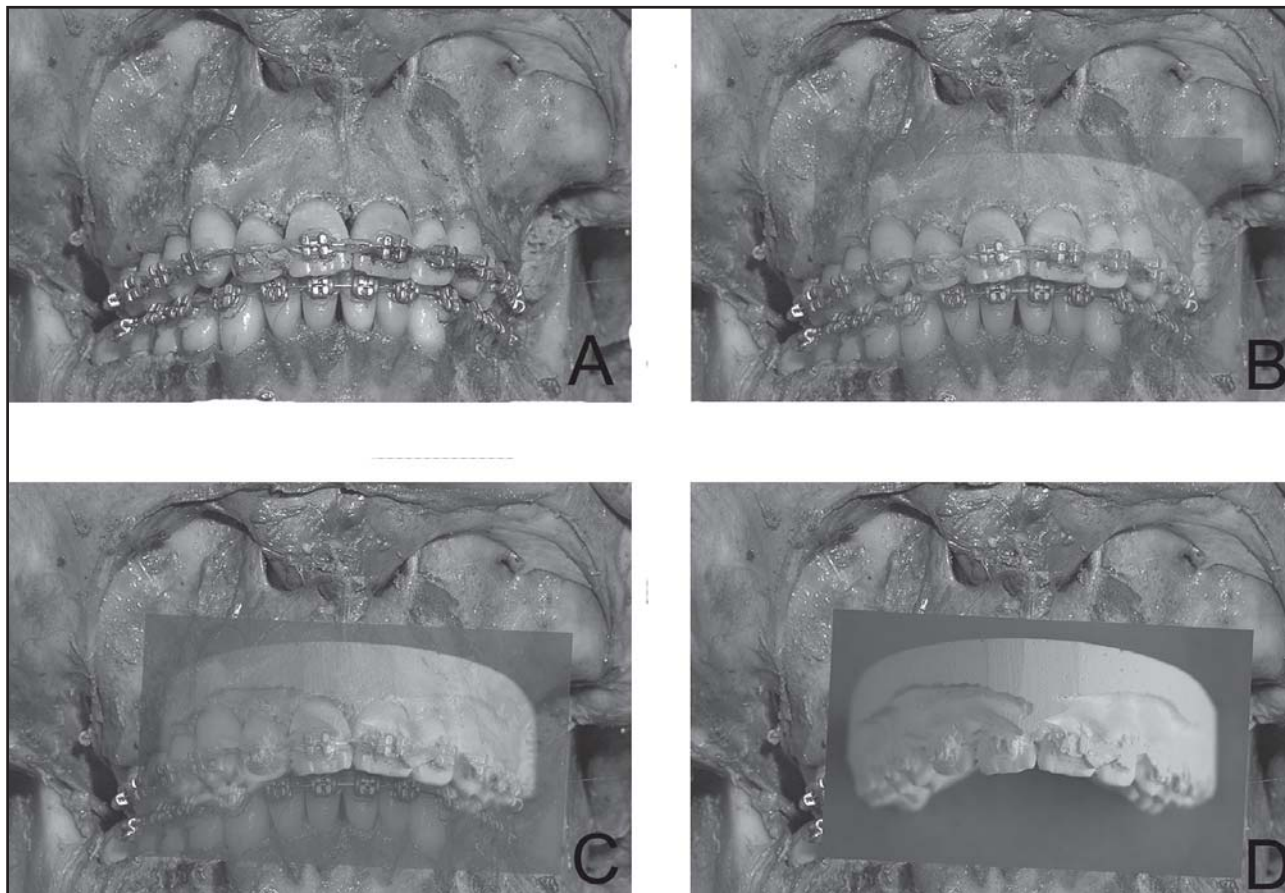


Fig.2: Case two. A through D show increasing ratio of opacity while superimposing an antemortem model of upper jaw onto postmortem remains. Opacities were for: A 1%, B 30%, C 60% and D 100%

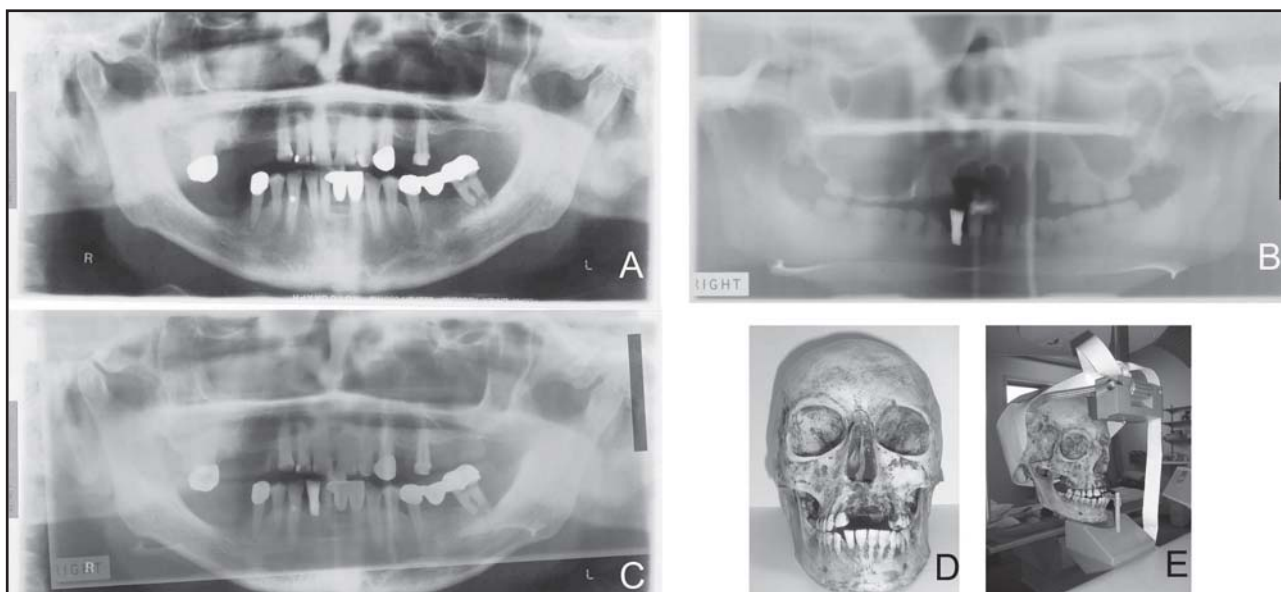


Fig.3: Case three. A antemortem OPG, B postmortem OPG of an acrylic mandible and skull with tooth 42 embedded in its assumed anatomical position, C superimposition of both radiographs at opacity 50% showing consistent outline of tooth 42 without resizing either image. D and E show tooth 42 embedded in the acrylic mandible during radiography

background layer. The **opacity** slider on the layers palette gives values ranging from 0% to 100% transparency. Values in between will allow the operator to see the outline of both images while moving, rotating and resizing the overlaid image.

Anterior teeth are attempted to be matched by trial and error until the outline of both antemortem and postmortem teeth is consistent or otherwise. When sufficient concordance between anterior teeth is reached, other anatomical landmarks are examined for consistency. Magnifying a field might be useful and can be achieved using the **zoom** tool. This technique is illustrated in Figure 4 (For further details on relevant tools of Adobe® Photoshop® the reader is advised to visit ref. 12).

DISCUSSION

In a review, Taylor and Brown¹ discussed attempts to superimpose a face in a photograph taken during life onto a skull to determine if there was concordance between the two. The technique involved hand tracing the outline of the skull and that of a portrait followed by overlaying them using transparent paper. Photographic superimposition

gained special attention when it was employed in a homicide case for the first time in 1937.² When introduced in the seventies, video superimposition revolutionised this identification technique by allowing it to become a “live” process.³ This technique involved one image being viewed continuously while the other one was being incorporated. It produced a more realistic result simply and quickly by avoiding standard photographic methods and provided better comprehension of the identification procedure by a lay audience, such as a court jury. This technique, however, required expensive equipment and technical expertise, which was sometimes difficult to justify due to the infrequency of cases requiring superimposition.

The technique described in this paper is based on specific features of the Adobe® Photoshop® image editing software and is performed using a basic personal computer. It is a comparison of two digital images by over-laying one onto another using the program’s multilayer function. The opacity is reduced to allow semi-transparency and then maximum concordance is reached -or otherwise- by resizing and rotating the overlaid image by trial and error.

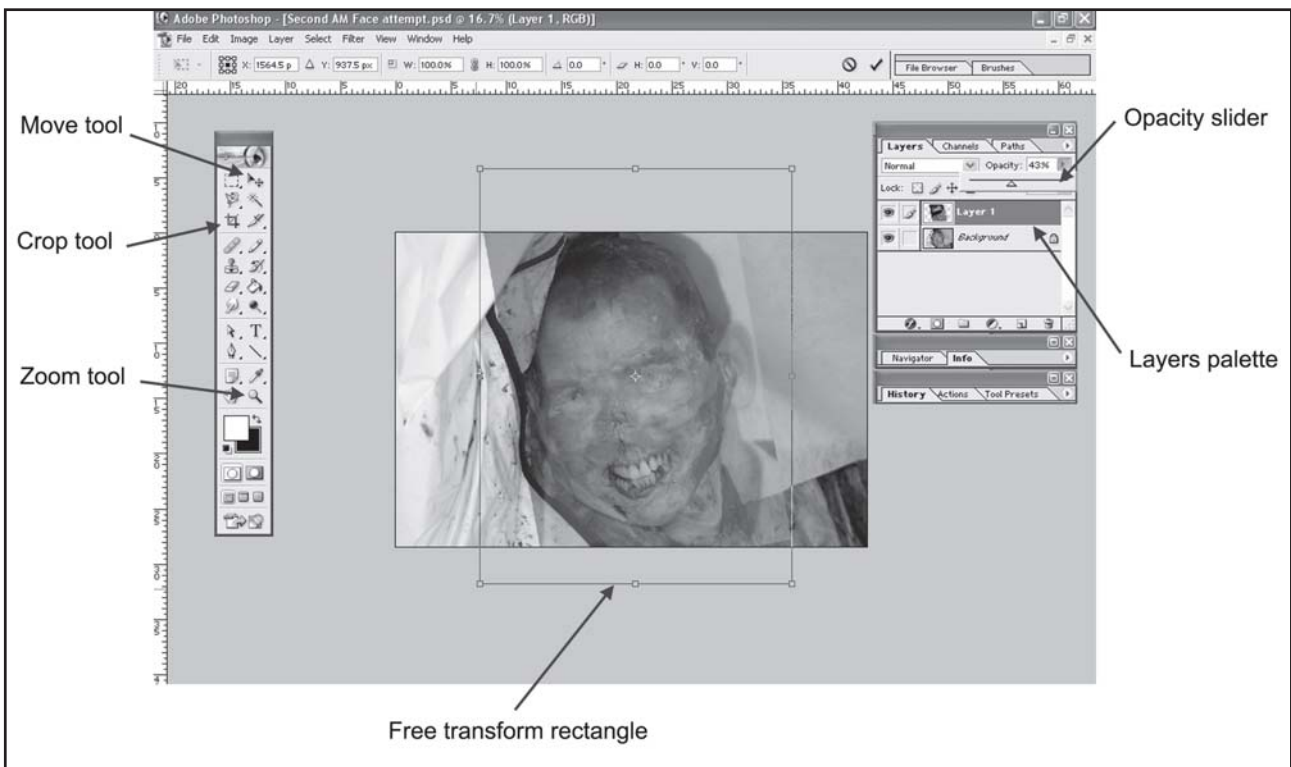


Fig.4: tools used for Adobe® Photoshop®-mediated superimposition illustrated on case one

Demonstrating the steps which lead to the conclusion that identity is established or not is a valuable advantage of this technique when an expert opinion is requested by a legal system.

Reproducing the same camera angle of the antemortem photograph and reaching a 1:1 scale between antemortem and postmortem images are the two major steps for any superimposition attempt and much work had been done to facilitate those two steps.³⁻⁵ Forensic experts have attempted to use objects within the vicinity of the face at approximately the same distance from camera.^{2,6} McKenna *et al* used the anterior dentition as a guide to enlarge and to match images by tracing the outline and comparing anatomical landmarks.⁷ Their approach was based on the fact that the upper anterior teeth are the only hard tissues that project from the skull and can be analyzed from both antemortem and postmortem images. In the method described in this paper, anterior teeth are of paramount value. They will not only serve as a reference to reach 1:1 relation between the two images, but also as a key to rotate the overlaid image over the background image in order to reproduce the angle on the x and y axes. If the skull and the photograph belong to the same individual, then all other facial anatomical landmarks should be in the best fit possible as was demonstrated in case one.

This technique was beneficial in the identification of few of the victims of the Indian Ocean tsunami (December 2004). Portraits of smiling faces (with the anterior teeth showing) compensated for the lack of dental records which can be expected when a disaster affects certain communities with little or no dental work or with poor record keeping (case one). The technique proved useful in identifying children who would normally have no restorative dental work done as was shown in case two, and more importantly, it is a technique that is simple to learn and perform and can substitute the sophisticated equipment used in video superimposition.

Forensic odontology is based on the fact that teeth are unique to each individual.⁸ Unfortunately we could not find any studies that investigated the pattern uniqueness of anterior teeth, mainly the upper anterior teeth that usually appear in smiling portraits. For this reason, forensic experts must select candidate cases carefully should the need for superimposition arise. Photographs showing the anterior teeth have to be clear and in focus, with good resolution and well illuminated. An anomaly, as in case one, or a special pattern, as in case two,

suggest the use of superimposition, but it must be remembered that teeth and their positions are changeable during life either accidentally (falls), intentionally (dental treatment including orthodontics) or as part of growth (closure of a median diastema). It is essential to make certain that the antemortem photographs, or models as in case two, are recent. Cases whereby anterior teeth are absent (either antemortem or postmortem), or are not showing in portraits are not suitable for identification with this method.

Seeking more than one photograph of the suspected deceased individual and from different angles will produce reliable results. In one study, video superimposition, without using anterior teeth, resulted in 9.1% false positive identifications. This dropped to 0.6% when a second antemortem photograph from a different angle was used.⁹

Reproducing the camera angle from which the antemortem portrait was taken is by trial and error. In our first two cases, we made a series of digital photographs following an imaginary grid which helped produce images from different view angles. Several images of those were then selected and each attempted to superimpose onto the antemortem portrait (case one) and postmortem image (case two). Previous studies have suggested methods in an attempt to make this step easier.^{3-6,10}

Quantifying superimposition was attempted previously.^{7,11,13} Adobe® Photoshop® provides measuring tools which are described by Johansen and Bowers for bite mark analysis¹² and radiographic comparisons.¹³ In the cases presented in this paper we did not perform measurements. More work needs to be done to utilize those tools to reach reproducible and quantitative results.

Case three is an application of this technique to superimpose radiographs and study the outline of teeth. Objective comparison between antemortem and postmortem radiographs was previously performed using Adobe® Photoshop®¹³. In our case, the same OPG machine with the same settings was used to produce the antemortem and postmortem radiographs. Hence we assumed that -without resizing either image- the outline of the tooth in the postmortem OPG would not fit that of the alleged victim if both teeth belonged to different persons. The outcome, as shown in Fig. 3, demonstrated satisfactory concordance between both radiographs, which proposed a positive identification.

The remarkable increase in the use of digital cameras has made photography a fashionable hobby. The availability of portraits, as a consequence, is becoming an antemortem record worth considering in craniofacial identification. The method we used here demonstrates the use of Adobe® Photoshop® as a user-friendly tool to overlay antemortem and postmortem images and to analyze their consistency in a reliable, speedy and easy manner which might compensate for the lack of comparable dental records. Further studies are required to determine the specificity and sensitivity of this technique.

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