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Forensic anthropology population data

Relevance of Whitnall's tubercle and auditory meatus in diagnosing exclusions during skull-photo superimposition

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ABSTRACT

Video vision mixer based skull-photo superimposition is a popular method for identifying skulls retrieved from unidentified human remains. A report on the reliability of the superimposition method suggested increased failure rates of 17.3 to 32% to exclude and 15 to 20% to include skulls while using related and unrelated face photographs. Such raise in failures prompted an analysis of the methods employed for the research. The protocols adopted for assessing the reliability are seen to vary from those suggested by the practitioners in the field. The former include overlaying the skull- and face-images on the basis of morphology by relying on anthropometric landmarks on the front plane of the face-images and evaluating the goodness of match depending on mix-mode images; the latter consist of orienting the skull considering landmarks on both the eye and ear planes of the face- and skull-images and evaluating the match utilizing images seen in wipe-mode in addition to those in mix-mode. Superimposition of a skull with face-images of five living individuals in two sets of experiments, one following the procedure described for the research on reliability and the other applying the methods suggested by the practitioners has shown that overlaying the images on the basis of morphology depending on the landmarks on the front plane alone and assessing the match in mix-mode fails to exclude the skull. However, orienting the skull relying on the relationship between the anatomical landmarks on the skull- and face-images such as Whitnall's tubercle and exocanthus in the front (eye) plane and the porion and tragus in the rear (ear) plane as well as assessing the match using wipe-mode images enables excluding that skull while superimposing with the same set of face-images.

1. Introduction

The photographic method of superimposition devised by Glaister and Brash in 1935 [1], has now been replaced by the real time video process that has gained preference among majority of the practicing identification experts [2–23]. Research on the reliability of this method by Austin-Smith and Maples [16] suggested about 9% probability of failure to exclude identification while superimposing 98 front view photographs of living individuals with 3 skulls. A recent report by Gordon and Steyn [24] superimposed forty digitized face photographs with 3D digital images of 10 skulls (10 photos were correct matches) for a total of 400 superimpositions for each of the morphological and landmark methods and suggested 17.3% and 32% failures to exclude (false positives) for the morphological and landmark methods, respectively. In addition, failure to include (false negatives) was 15% and 20% for the morphological and landmark methods, respectively. Review of regular practice of superimposition method reveals it's utilization in about 2307 real cases in different parts of the world [9,12,17,18,25,26] with court testimony in India reaching 200 [27]. Routine application of this method has been described by more authors [21,28–30] even though the number of cases has not been mentioned. Thus far, a single wrong identification has been reported albeit without detailing the method used [31]. While opinions based on superimposition method are sustaining in most of the real-life cases, the higher rates of failures suggested by Gordon and Steyn [24] prompted a comparison of their methods with the methods popular among the practitioners. Essential variances in the methods adopted by Gordon and Steyn [24] include the application of landmarks on the front plane of the face seen on mix-mode images for verifying the goodness of fit *after* obtaining the match while the practitioners [6,9,13,20,23] have

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relied on the landmarks on the front (eye) plane as well as the rear (ear) plane for orienting the skull *before* obtaining a match for evaluating the match depending on images in wipe-mode. In this research, an archived skull was superimposed with five face photographs of living individuals in two sets of experiments, one following the practitioners' method [6,9,13,20,23] and the other applying the method described by Gordon and Steyn [24] to assess the relative efficiency in excluding identification.

2. Materials and methods

2.1. Study sample

An archived skull marked 'I' utilized during the two sets of experiments was obtained from Forensic Unit, Pulau Pinang Hospital, Malaysia (Courtesy: Dato' Dr. Bhupinder Singh, Consultant Pathologist, Pulau Pinang Hospital, Pinang) (Approved by Human Ethics Committee, Universiti Sains Malaysia in USMKK/PPP/JEPeM [201.3.(6)]). The teeth in the skull were relatively intact and natural occlusion was achieved while articulating the mandible with the cranium using a piece of dial cord spring on each side fastened with two 5 mm metal wood screws, one posterior to the fronto-parietal suture in the cranium and the other in the medial aspect of the mandibular rami below the coronoid process.

Five face photographs of living individuals selected for this study were from normal adult male volunteers aged between 20 and 27 belonging to Chinese (CF, CH, CI), Indian (IC) and Malay (MG) racial affiliations collected during a previous research (Approved by Human Ethics Committee, Universiti Sains Malaysia in USM/PPP/Ethics Com./2009 (141). The subjects were photographed seated in repose utilizing a Nikon D70S camera (Nikor 35 mm lens) with a subject lens distance of 1.76 m. The lighting was of studio grade and the lens was maintained at the same level as the face of the subject. The digital face-images were appropriately cropped, transformed to grey scale and balanced in auto level mode in Adobe Photoshop® CS3 and were saved on a local computer.

2.2. Methodology

The racial affiliation of the unidentified skull was assessed as Mongoloid by scoring the non-metric traits adopted by Burns [32]. Sex of the skull assessed by scoring the morphological traits described by Novotny et al. [33] indicated masculine features. Craniometric studies of the skull following Krogman and İşcan [34] revealed a mid-face (total facial index: 85.71) and a wide nose (nasal index: 52.94). Cranioscopic observations following Jayaprakash et al. [20] revealed shallow frontal lines and absence of frontal eminences, rocker jaw and gutter evidence in the floor of the piriform aperture. The mental triangle had a moderate base. Asymmetries observable on the basis of differences between the right and left sides included those in the prominences of the brow ridges, zygomatic arches, extent of eversion in the gonion, prominence of the nasal ridge, width and lower levels in the piriform aperture and inclination of the nasal spine. Cephaloscopic observations made utilizing A4 size enlargements of the five face-images indicated variations in the facial forms in all of the five faces definable into five categories: circular, ovoid, narrow ovoid, slightly pentagonoid and moderately pentagonoid. The degree of conspicuity of the nasion in the face-images ranged from less prominent to prominent. The noses in four of the face-images were assessed as broad and in the fifth it was medium. Asymmetries of varying degrees could be observed particularly in the nasal and gonial zones in every face-image. The tragus was visible either in the right or left side of four face-images and the location of the tragus in the remaining face-image was obtained by measuring it in a scaled lateral view photograph of that individual available on record.

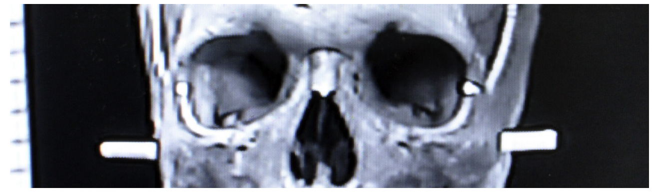

Fig. 1. Image of skull 'I' seen on the TV screen showing the marking of Whitnall's tubercles and the indication of the auditory meatus.

The skull 'I' was superimposed with the face-images using the Computer Aided Video Superimposition Device (CAVSD) in two sets of experiments. The design of the video superimposition device followed the one described earlier [20] and the addition of computer has been detailed subsequently [35]. Whitnall's tubercle in the skull was located by visual inspection followed by palpating the orbital rim. The tubercle itself measured about 3 mm in diameter horizontally and vertically the border of the tubercle gradually merged with the orbital rim. The tubercle was marked with white water color (about 3.2 to 3.6 mm in diameter) and the auditory meatus in the skull was indicated by a paper roll inserted into it (Fig. 1). The zygion, recognized as the farthest point in the width of the skull in the region of the zygomatic arch, was marked with a marker pen. Here, the marking included the entire width of the zygomatic arch in the zygion region so that the marking will be observable in the superimposed state distinguishing the zygion from the mastoid region which, being a similar bony area in the background, can confuse recognizing the zygion in frontal view. Distinguishing the zygion region is important in assessing the symmetry in tissue thickness along the two zygomatic regions in front view face-images for assessing the match during superimposition. In the enlarged face-images printed in A4 size papers, the exocanthus – located in the lateral aspect of the outer commissure of the eye angle following the white of the eye – was marked with black ink (about 1.0 to 2 mm in diameter) and encircled utilizing white water color (about 3 to 4 mm in diameter) to enhance visibility during superimposition (Figs. 2 and 3a–c). The point in the outer commissure lateral to the white of the eye was preferred here as, further laterally, the outer commissure revealed greater degree of shade distribution impeding the location of a precise point. The upper slope of the tragus viz. the border of the tragus superior to the eminence seen in the printed face-image was marked with a black marker (Fig. 2). The printed face-image was pinned onto an improvised vertical stand and its image captured using a CCD camera was cast on a 32 in. LCD TV screen. The two pupils in the face-image were adjusted to the same horizontal plane by utilizing the wipe facility in the vision mixer and, alongside, manipulating the print. The image of the skull was captured employing another similar CCD camera and its size on the TV screen was magnified to correspond to the actual size of the

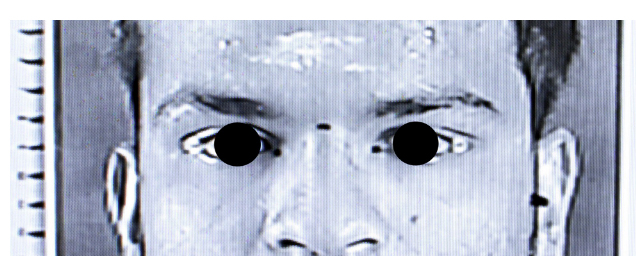

Fig. 2. A face as seen in the TV screen illustrating the markings on the exocanthus and tragus.