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TECHNICAL NOTE

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GrinLine Identification Using Digital Imaging and Adobe Photoshop*

ABSTRACT: The purpose of this study was to outline a method by which an antemortem photograph of a victim can be critically compared with a postmortem photograph in an effort to facilitate the identification process. Ten subjects, between 27 and 55 years old provided historical pictures of themselves exhibiting a broad smile showing anterior teeth to some extent (a grin). These photos were termed "antemortem" for the purpose of the study. A digital camera was used to take a current photo of each subject's grin. These photos represented the "postmortem" images. A single subject's "postmortem" photo set was randomly selected to be the "unknown victim." These combined data of the unknown and the 10 antemortem subjects were digitally stored and, using Adobe Photoshop software, the images were sized and oriented for comparative analysis. The goal was to devise a technique that could facilitate the accurate determination of which "antemortem" subject was the "unknown." The generation of antemortem digital overlays of the teeth visible in a grin and the comparison of those overlays to the images of the postmortem dentition is the foundation of the technique. The comparisons made using the GrinLine Identification Technique may assist medical examiners and coroners in making identifications or exclusions.

KEYWORDS: forensic science, odontology, photographic comparison, forensic identification, digital imaging, GrinLine

When a forensic dentist is asked to aid in identification, the success of that effort relies upon accurate antemortem (AM) and postmortem (PM) records. The process is hindered when no AM dental records exist.

The goal of this study was to describe a technique, the GrinLine Identification or GLID technique that can serve as another tool in the forensic odontologist's armamentarium. The technique compares grins seen in earlier or AM photographs with photographs of PM anterior teeth made by or under the direction of a forensic odontologist.

Improvements in digital technology and software have greatly improved analysis and processing techniques for imaging and management of photographic data. Adobe Photoshop will be used for enhancing, analyzing, and comparing photographs of grins. According to Princeton University, the mechanism required to create a grin is: "To draw back the lips and reveal the teeth in a smile, grimace, or snarl" (1).

The AM photographs of the subjects selected for this study were of varying quality and presented many challenges with respect to analysis. It was necessary to determine what features to look for in the photographs and which tool or combination of tools in Adobe Photoshop could help to size, enhance, and compare the images.

Methods

Ten individuals provided historical photographs that had been created within the previous 8 years. The subjects had no anterior restorations placed after these photographs were taken. These photographs became the "AM" images.

A SONY DSC-VI digital camera with a 5.0 megapixel resolution was used to photograph each subject's anterior teeth using a variety of orientations and camera angles. These photographs were used as the "PM" photographs. Each photograph was exposed at a slightly different angle in an effort to increase the chances of reproducing a perspective that would be similar to the orientation seen in the "AM" photographs.

A single set of "PM" photographs was randomly selected as the "unknown" victim. An attempt would be made to "identify" this unknown by comparing the "PM" images with the "AM" images and their respective overlays and evaluate them for concordant features.

This sequence of steps was followed for each image:

1 The AM and PM images were imported into the computer and archived.
2 The grins in the AM images were cropped and archived.
3 All images were enhanced utilizing the LEVELS tool.
4 The images were sharpened if needed.
5 The AM images were sized using common reference points and features seen in the PM image.
6 The AM overlay was created.
7 The overlay was compared to the PM image for concordant features.
8 All working images were archived.

Digital adjustments to images are more consistent and dependable when a prescribed sequence is followed.

Importing the Images

Both the AM and PM photographs were digitized. The AM photographs were digitized by either scanning in the photo using a

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Canon LiDE flatbed scanner at a minimum 300 dpi resolution or by taking a digital photograph of the image with the camera set at its highest setting. The PM photographs were imported directly from the camera's memory card. It is important to work with high resolution images to provide the best clarity and reduce pixilation at higher magnifications.

When the AM images were from a newspaper or other mass production printed source, the images captured using the digital camera were superior to those made by scanning the material.

AM Photo Quality Issues

The quality of the imported AM images varied and that issue was addressed using the various tools available in Adobe Photoshop (2). Some images will require only basic adjustments.

Cropping the Image

The CROP tool allows isolation of the grin by selecting only that part of the photo that includes the grin. In the IMAGE drop down menu, IMAGE SIZE was selected (IMAGE > IMAGE SIZE). The cropped image was enlarged and saved as a tiff file. Figure 1 illustrates the original and resulting cropped and enlarged grin image.

Setting Levels

Contrast and brightness issues were addressed using the Levels command. Select IMAGE > ADJUSTMENTS > LEVELS. This command allows you to optimize shadows, midtones, and highlights in the picture by moving the sliders at the bottom of the histogram. Adjusting the levels controls manually allows for more flexibility than using the AUTO button alone. The BRIGHTNESS/CONTRAST adjustment command should not be used for brightness and contrast issues as information in the image can be lost (3). Figure 2 shows the sliders for manual control at the bottom of the histogram.

Sharpening the Image

The SHARPEN, UNSHARP MASK, and SPONGE tools can help a blurry image become more focused. Cropping and magnifying blurry images only compound the problem. Within the FILTER drop down menu, there is a SHARPEN > UNSHARP MASK filter. Sharpen filters help to clarify images by enhancing the contours. The SPONGE tool can increase the saturation or intensity of a color. This tool was utilized in an attempt to accent the areas beyond the shape of the teeth. That is, it intensifies the colors at the incisal and/or gingival of each tooth to make measuring the widths and lengths easier when sizing the images.

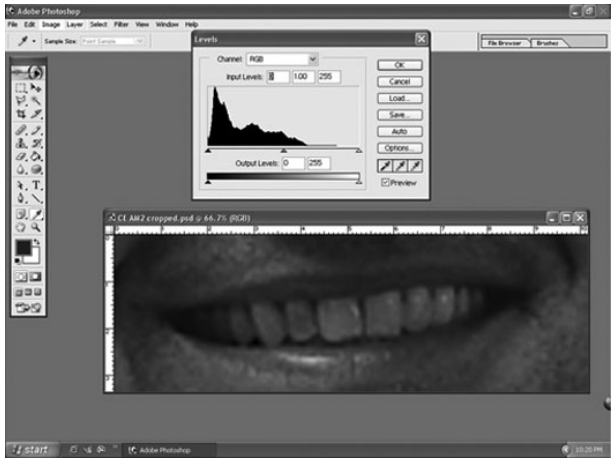

FIG. 2—*The sliders on the histogram are moved to lighten or darken an image.*

Sizing the Image

Once the AM and PM photographs were acquired and any quality issues were addressed, it was necessary to adjust the size of the AM teeth to the same size as the PM teeth. A PM photograph was selected that appeared to approximate the perspective or projection geometry of the AM photo. The AM image was also rotated to duplicate the horizontal incisal plane present in the PM image (Fig. 3). This allows the measuring guides to line up in the X/Y axis and allows more accurate sizing of the two images. Using the RECTANGULAR MARQUEE tool, outline the AM image. Then select EDIT > FREE TRANSFORM and move the cursor to a corner where a curved double arrow appears. Left click and hold while moving the image to the correct plane. Select ENTER then CONTROL D to remove the "marching ants." To resize in the

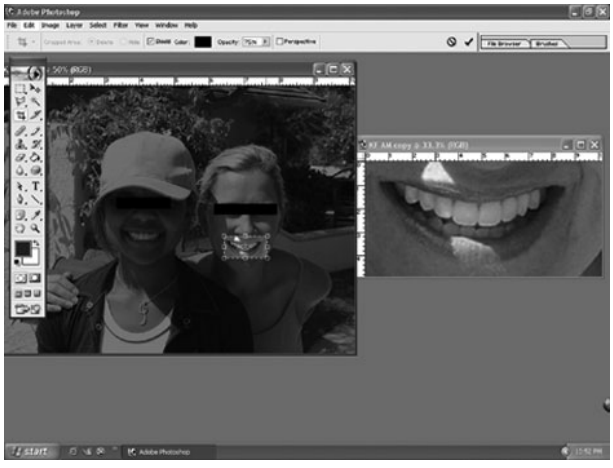

FIG. 1—*The grin found in the AM image is cropped and magnified.*

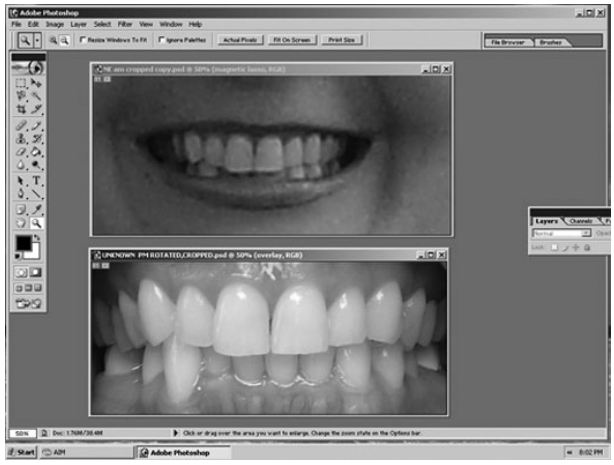

FIG. 3—*The size discrepancy is obvious between the cropped and rotated AM and PM images.*

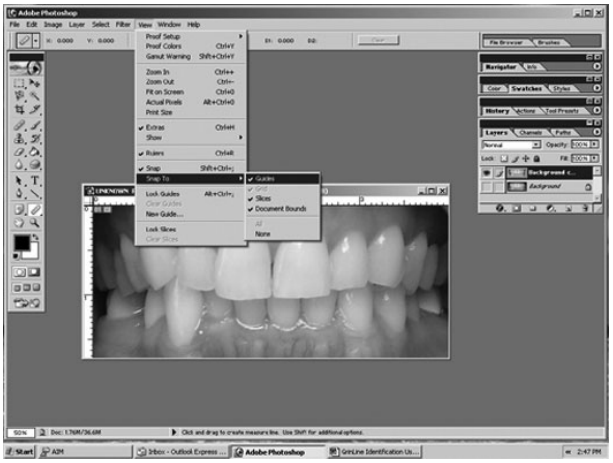

FIG. 4—*SNAP TO and GUIDES can be found within the VIEW drop down menu.*

VIEW drop down menu, RULERS were checked then SNAP TO > GUIDES. The Measure Tool was selected (Fig. 4).

The guides were dragged to measure the width of tooth #8. This width was read on the information bar at the top of the screen at D1 and found to be 0.633.

The AM image was then highlighted and the same sequence was followed to determine that the D1 width of the AM tooth #8 was 0.340 (see Fig. 5 arrow). Figure 5 shows the AM and PM views on the same screen before the resizing.

Next the AM dentition is converted to the same size as the PM dentition by applying a Resize Ratio (4). This ratio is defined as SCALE SIZE (ACTUAL) divided by SCALE SIZE (IMAGE). This translated to the size of the PM divided by the size of the AM or, in this example, 0.633/0.340. The resultant factor of 1.86 was multiplied by the width of the overall AM image as found in the IMAGE SIZE box (Fig. 6). Constrained Proportions was checked in order to ensure the entire image was enlarged proportionately and the corrected value was entered into the highlighted width. Applying that change gave a corrected size for the AM image that made it the same size as the PM (Fig. 7). It is not necessary for these to be life-size, just ensure that they are the same size.

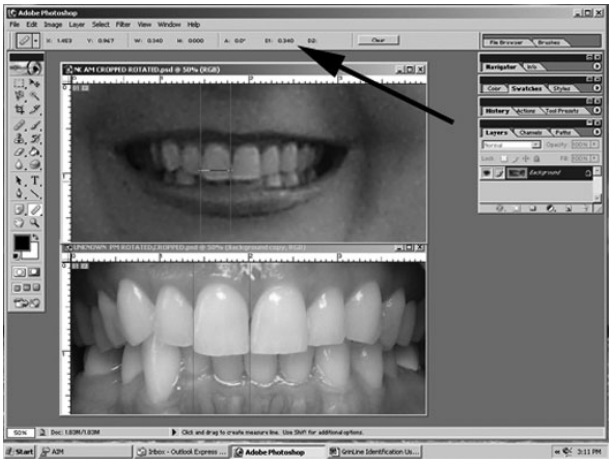

FIG. 5—*The measuring guides have been placed to determine the width of #8 on each image. The arrow points to D1, the width measurement, for the activated AM image.*

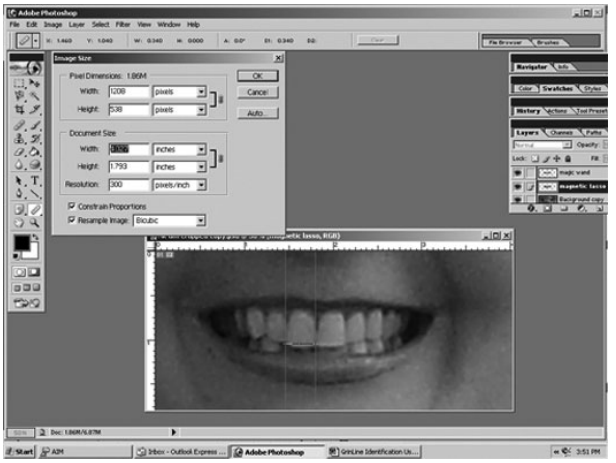

FIG. 6—*The width value that is highlighted in this AM image will be multiplied by the Resize Ratio. That new number is entered into the width box and the overall image will adjust in size.*

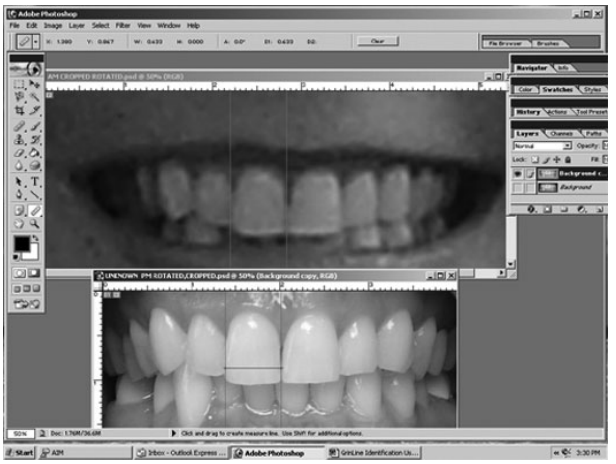

FIG. 7—*The AM and PM images are now the same size.*

This example shows sizing of the images along the width. However, you can size along the width and the height and can use more than one tooth. For example, you could size the image using the distance from the cusp tip of tooth #6 to the cusp tip of #11 if you felt that was easily seen on both images. It is necessary to work with each image to determine what is best for that subject.

Making the Overlay

Now, with the image sizes coordinated, the AM overlay was made. Many odontologists are familiar with acetate overlays and their use in evaluating bite mark images. This technique utilizes the computer software to produce an overlay and facilitate a digital comparison.

The teeth on the sized AM image are outlined and isolated by using any number of tools in Photoshop. A PEN tool, MAGIC WAND, or POLYGONAL LASSO are just some options that can be used (4). Once the teeth were isolated, a new photoshop layer is created (LAYER > DUPLICATE) and it is named OVERLAY. Unclick the eye on the background layer and the overlay layer remains visible with the entire grin still present. The area outside of the magic wand outline is deleted by using SELECT > INVERSE

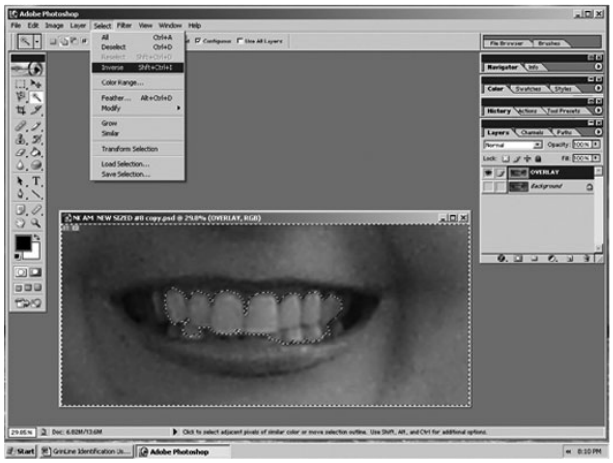

FIG. 8—*The MAGIC WAND Tool is used to outline the teeth within the grin.*

from the drop down menu (Fig. 8). Then select EDIT > CUT and this will leave you with a layer that shows the isolated teeth.

In the OVERLAY layer, the isolated AM teeth were magnified to a level that was comfortable to work in and then, using an ERASER tool, the contours of the teeth were defined (Fig. 9). Once the outline of the AM teeth is complete, the PM sized image is brought up on the same Photoshop screen.

The opacity of the AM overlay can be changed to the point where it is possible to see through it to the underlying PM image. The opacity slider is found in the Layers palette and is a simple way to see through one semi-transparent layer to another underlying layer. Setting the slider at approximately 50% is usually sufficient. The AM image is activated and, using the MOVE tool, the left mouse button is held down and the AM overlay is dragged over onto the PM image. The AM overlay is now superimposed over the PM image (Fig. 10).

Figure 11 shows the cropped images that were used in the entire GLID process, culminating in an illustration of the beginning of the overlay movement and then the final superimposition. An evaluation for any concordant points can be done with the final overlay superimposition.

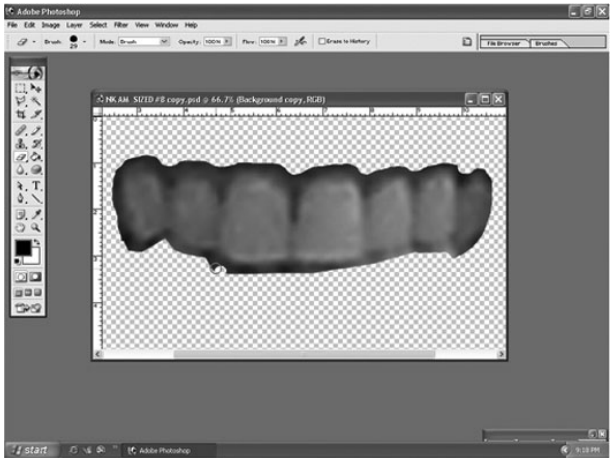

FIG. 9—*The ERASER Tool can be used to define the contours of the teeth. Doing this at high magnification is advised.*

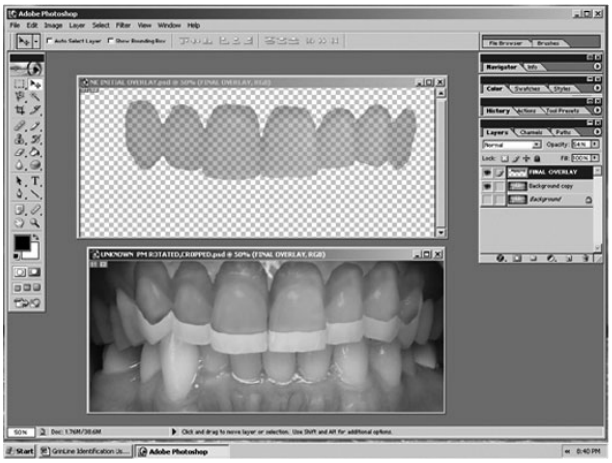

FIG. 10—*The AM overlay is brought down and superimposed over the unknown PM image.*

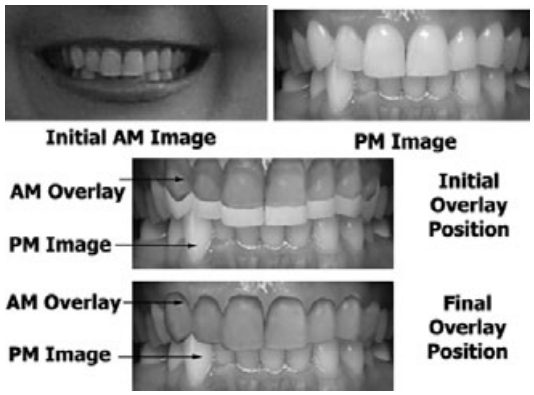

FIG. 11—*The GrinLine ID process produces an AM overlay to compare against a PM image.*

Discussion

Working with Dual Arches

When AM images depict both mandibular and maxillary arches, both arches can be compared using the overlays. Viewing and comparing the incisal edges of the mandibular teeth is very helpful as there are often more variations with those anterior contours that can aid in the comparison process.

Although in Fig. 12 AM photo the area showing the grin was rather small and the image was slightly blurry, an analysis was still possible. The dual arch final overlays have numerous concordant points in the comparison with the PM image. The probability of conveying information to medical examiners or coroners to aid in identifying this individual is very high.

Using GLID

In a hypothetical scenario involving fragmented remains, the fragment of the dentition may be compared to multiple AM subjects by following a similar technique. Import the PM photo into Photoshop and select any saved AM images that show the cropped and sized AM grins and overlays. In the example below, four AM grins are opened in the same window as the unknown PM (Fig. 13). The perspective may be slightly different for each AM subject. At this stage, this screen is used as a quick way to evaluate

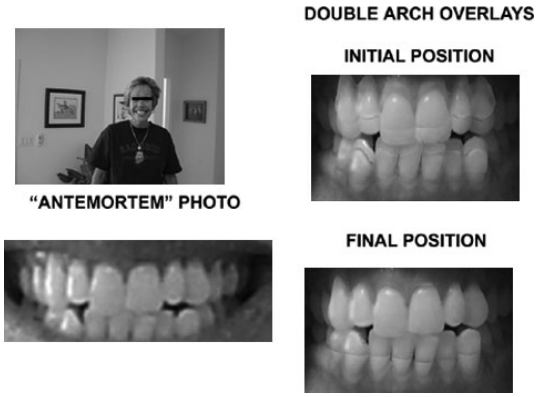

FIG. 12—*Dual arch overlays can provide more points of comparison.*

FIG. 13—*One screen can be used to compare several AM images against an unknown PM.*

the incisal contours and individual characteristics of the subjects. Figure 14 shows each of these subjects with their corresponding AM overlays.

To perform the comparison, one overlay is activated and dragged using the MOVE TOOL over the PM photograph. Holding down

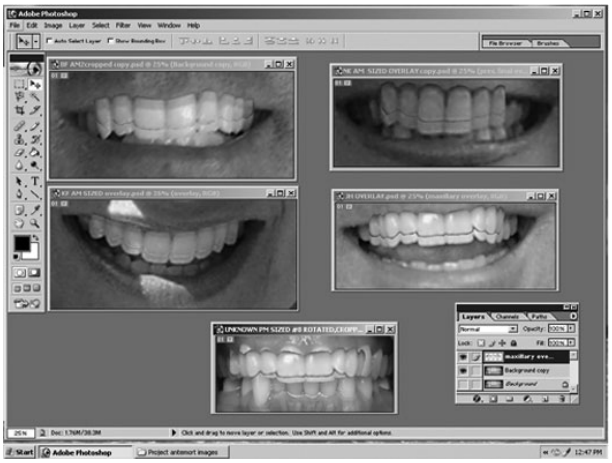

FIG. 14—*The AM overlay labeled ''JH'' is positioned over the PM image and does not reveal any concordant features.*

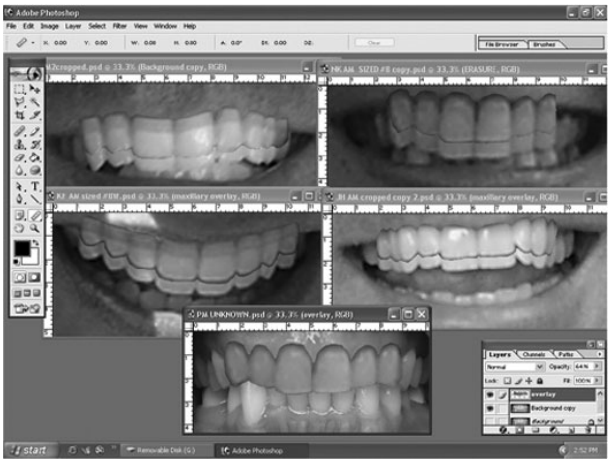

FIG. 15— *The GLID process has determined that the AM overlay labeled ''NK'' shows the most concordance with the unknown.*

the left mouse button allows the overlay to be moved into position. The arrow keys allow incremental horizontal and vertical position adjustments. The rotational plane for each overlay can be altered using EDIT > FREE TRANSFORM. A new layer is automatically produced on the PM image. Figure 14 shows an AM overlay superimposition that exhibits insufficient correspondence against the PM image. This overlay layer can be deleted and another overlay imported until a satisfactory comparison is achieved.

Figure 15 illustrates the overlay with concordant points. Should one of the overlays appear similar but the perspective improper, another sized PM photo exhibiting a more nearly correct angle may be selected from the folder of sized and bracketed PM images. The AM overlay can then be superimposed over the newly acquired PM image.

Results and Recommendations

The GLID describes a method to compare photographic images of the grins of individuals as seen in commonly available photographs to specific criteria-created images of the anterior teeth of unidentified deceased persons. This is done with the goal of aiding medical examiners and coroners in identifying those persons.

Points to consider when applying the GrinLine Technique include the following:

- A recent full-face close-up photo showing a wide grin is the most useful AM image for the GLID analysis. Collection and archiving of these images by law enforcement and other agencies for their missing persons and AM data banks could prove valuable.
- Depending upon the quality of the scanner and the digital camera, the best AM working image *may* be a digital photograph of the original image. This is especially evident when dealing with newspaper or other printed photos.
- PM photographs should reproduce the perspective variations that could be found in an AM photograph. To accomplish this, multiple photographs should be made using step-wise increments in horizontal and vertical angulation.
- The forensic photographer usually has only one opportunity to collect information. It is important to use the time wisely and make many exposures.
- Each AM image provides challenges with respect to analysis. It is beneficial to become familiar with all of the tools in Adobe

Photoshop or other image analysis software in an attempt to address those problems.

- Both maxillary and mandibular arches can be analyzed. The chance of reaching a conclusion that helps to lead to identification is greatly increased when multiple individual characteristics are visible in the AM image.
- The ability to see all of at least one tooth is preferable for sizing a comparison image but may be accomplished with a single dimension. The GLID analysis can be employed using PM photographs of dental fragments provided there are a sufficient number of teeth (usually three or more) and those same teeth are visible in an AM grin photograph. Loose individual or multiple teeth out of their sockets with no ability to "reassemble" them into their correct positions would not be of value in this technique.
- Forensic odontologists must remain aware of the possibility that any AM photograph may show an anterior dentition that has since been replaced with restoratives. Careful investigation into the time of placement of restorations is vital for a valid GLID comparison.
- GLID is a software-assisted manual technique that works best in individual cases or in limited populations of unknowns.

Finally, the Guidelines for Body Identification published by the American Board of Forensic Odontology recommend four possible conclusions as to identity: Positive Identification, Possible Identification, Insufficient Evidence, and Exclusion. Because of the limitations of the technique, no statement of Positive Identification should be made utilizing GLID alone. The findings Possible Identification, Insufficient Evidence, and Exclusion *are* reportable as recommendations based upon GLID. The final decision on identification lies with the Medical Examiner or Coroner who must consider all factors. GLID is but one of those factors and the significance and value of the GLID is directly related to the quality of the evidence and the forensic examiner's careful attention to detail.

Disclaimer

None.

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