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Postmortem identification : an HTML-based dental computer program designed to assist in establishing the identity of missing children when decomposed or skeletal remains

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POSTMORTEM IDENTIFICATION: AN HTML-BASED DENTAL COMPUTER PROGRAM DESIGNED TO ASSIST IN ESTABLISHING THE IDENTITY OF MISSING CHILDREN WHEN DECOMPOSED OR SKELETAL REMAINS ARE FOUND

A Project Report

Presented to the Faculty of the Department of Interdisciplinary Studies

San José State University

In Partial Fulfillment

of the Requirements for the Degree

Master of Arts

By

Kevin Whitten

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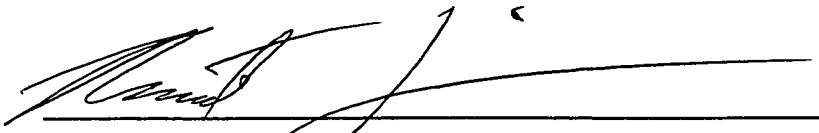
APPROVED FOR THE DEPARTMENT OF INTERDISCIPLINARY STUDIES



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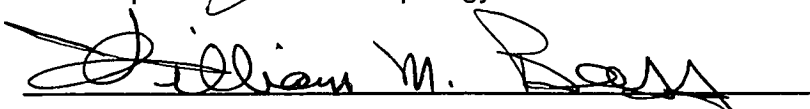

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ABSTRACT

POSTMORTEM IDENTIFICATION

by Kevin Whitten

The Forensic Identification National Database (F.I.N.D.) is a dental computer program designed to assist forensic science and law enforcement personnel in positively identifying human subadult remains when visual identification is unfeasible. The data source consists of antemortem dental "profiles" that the computer attempts to match with similar records obtained postmortem. When a database search establishes the most likely matches, the results are displayed in accordance with a highest-to-lowest confidence rating.

The aim of the program is to alleviate the otherwise labor-intensive task of manually comparing large numbers of ante- and postmortem dental records. Furthermore, the program's digital imaging capability facilitates a means for immediate identification by providing, via the Internet, the import of high-resolution radiographic printouts for comparison purposes.

ACKNOWLEDGEMENTS

A Forensic Science project like the one outlined in this report represents the coordinated efforts of many people; I would like to acknowledge here those who have contributed their time, effort, and/or ideas to what is the culmination of ten months dedicated work.

First, thanks are due to Boston-based applications engineer Bruce Ishikawa who loaned himself to the programming aspect of the project with skill, patience, and enthusiasm. Bruce recognized the project's enormous potential and was willing to devote both his time and labor free of charge.

A thank you goes as well to forensic odontologist Leon E. Pappanastos, DMD, who's many years of clinical and forensic experience ensured the accuracy of the program's dental component. In addition to many intuitive suggestions, Dr. Pappanastos also furnished the Panorex© radiographic materials that were incorporated into the program's "Missing Person" profiles.

I wish to thank my remarkable wife, Cindy, who is my gentlest critic, my understanding partner, my most patient sounding board, and my best friend. Cindy has been involved in the project since its inception and will no doubt play a pivotal role in any future marketing strategy.

My gratitude, also, to William M. Bass, Ph.D., for acceding to my request to join my committee despite his many pressing engagements. His warm

response to the concept of creating a dental computer program was the catalyst that set the wheels in motion. The continued support of Dr. Bass has been crucial to my career aspirations as well as to my academic growth.

The most appreciation, however, is reserved for my Graduate Chair, Robert Jurmain, Ph.D., who provided the adhesive that kept my graduate program together, guiding me through uncertain waters. Dr. Jurmain played an integral part in my decision to attend San José State, and I have not been disappointed. His professionalism, high standards, good counsel and humor have both inspired and prepared me for my quest. I have listened and I have learned, and for sharing with me his knowledge I am profoundly grateful.

DEDICATION

To all the families of the Nation's Missing:

Courage is the price that life exacts for granting peace.

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I. PREFACE

AS MANY AS 300 CHILDREN EACH YEAR are abducted by strangers, transported a distance of at least 50 miles, and murdered. Eighty percent of such youngsters are killed within the first 48 hours of their disappearance. Kidnapped children are most frequently under the age of 12, but sometimes are up to age 17, come from every ethnic and socioeconomic background, and are as likely to be seized in big cities as they are in small communities or isolated rural areas [1].

When a child is abducted, murdered, and the body disposed of a great distance from home, identification can prove to be an extremely arduous task. The prospects for identification are greatly increased when the remains are found in close proximity to the abduction site and when the postmortem interval is brief, since the environment, temperature, and moisture of all climates will take a considerable toll on a body. As the postmortem duration increases, the resultant decompositional processes render such recognizable characteristics as birthmarks, scars, or eye color unusable as visible identifiers. When only skeletal remains are recovered, a forensic anthropologist may provide valuable clues to the individual's identity by furnishing information indicative of sex, race, and approximate age at death.

However, sex and race markers are not diagnostic on the subadult skeleton, hindering the identification of children even further.

II. IDENTIFICATION VIA DENTAL COMPARISON

The Identity of a decedent can be established by a variety of methods, ranging from the simple to the highly sophisticated [2,3]. When a child is the victim, dental comparison is among the most viable means of identification, since dental records, unlike fingerprints, are ordinarily procured for everyday clinical use. Furthermore, teeth, in contrast to other physical characteristics, have shown to be very resistant to almost any kind of environmental assault [4]. This differential preservation is due, in part, to the hydroxyapatite content of enamel, which becomes calcified once formed [5]. Intraoral or radiographic examination of dental structures may reveal one or more of the following features:

- Tooth restorations
- Endodontic (root) canal therapy
- Fixed orthodontic or prosthetic appliances
- Crown, root, and pulp chamber morphology
- Diasthemas
- Pathologic conditions
- Tooth malocclusion

- Missing or unerupted teeth

Any combination of the above anatomical features, if sufficiently unique, may provide numerous concordant points of comparison and effect a positive ID [6-10]. Clinical records and radiographs must therefore be considered among the most practical identification methods in child homicide cases.

III. NATIONAL CRIME INFORMATION CENTER (NCIC)

The rise of computer technology has overturned physical and economic limitations on the ability of authorities to collect, organize, process, and distribute information, and since 1983, the FBI's National Crime Information Center (NCIC) has provided computerized assistance in matching unidentified remains with missing persons [11,12]. However, since its inauguration, a number of inherent problems with the missing and unidentified person aspect of the NCIC have been recognized. One of the major concerns lies with the requisite documentation for entering dental data, which has been described as being too elaborate and subjective in nature. In addition, the precision of the NCIC information requirements has been questioned, with data entry errors and mistakes made by personnel in completing the documentation being among the most frequently cited problems [13].

Concerns have also surfaced with regard to appraising dental information in the NCIC search routine. For example, a potential match is registered only if it meets a specific "threshold score." Qualifying factors include, among other things, blood type, corrective vision prescriptions, scars, marks and tattoos, and personal effects such as clothing and jewelry [14]. Since recovered remains have often experienced advanced decomposition, these classifications serve only to further complicate the NCIC search parameters as the program considers and weighs each of them when seeking a match between files.

IV. THE FORENSIC IDENTIFICATION NATIONAL DATABASE

The *Forensic Identification National Database* (F.I.N.D.) is an interactive, HTML-based prototype computer system, designed to assist forensic science and law enforcement personnel in the positive identification of missing children when decomposed or skeletal remains are found. At the time of a child's abduction, the program stores both written dental records and radiographs in a comprehensive, on-line database. These dental "profiles" are equated with similar records obtained postmortem. When a database search identifies the most likely matches, the results are displayed in accordance with a highest-to-lowest confidence rating. Those records with the most number of matching dental attributes will appear at the top of the

screen, followed, in descending order, by all other possible matches. The program's three search objectives can be summarized as follows:

- *Advanced Search*: A match is scored only if ante- and postmortem dental attributes correspond to within a 90 percent confidence rating. In order for the Advanced Search to perform successfully, the tooth surface location of any dental fillings must be entered with a high degree of accuracy.
- *Intermediate Search*: As with the Advanced Search, the Intermediate Search recognizes the precise location of all restorations. However, the lower confidence rating of the Intermediate Search is intended to identify possible matches even if teeth do not correspond exactly or if additional restorations are present. Consequently, the search results will not be significantly compromised by minor mistakes within the ante- or postmortem dental data.
- *Basic Search:* The least discriminating of the three search components, the Basic Search does not recognize individual tooth surfaces but rather the location of the tooth itself and its nonspecific restoration status (i.e. whether a tooth is filled or unfilled). This aspect of the search routine permits a wider discrepancy margin, allowing for such factors as data entry errors and/or ongoing changes in the dental profile; for example, the replacement of deciduous teeth with permanent teeth subsequent to the child's most recent clinical examination.

F.I.N.D. will not necessarily identify a single match to the exclusion of all others. The aim of the program is to recognize the most highly correlated records by excluding all conspicuous mismatches and so reducing the total for manual review to a manageable number. Thus, the system expedites the identification process by alleviating the otherwise labor-intensive task of manually comparing large numbers of ante- and postmortem dental records. Furthermore, the program's digital imaging capability facilitates a means for immediate positive identification by providing, via the Internet, the import of high-resolution radiographic printouts for comparison with postmortem X-rays. The electronic storage of dental radiographs makes their repeated solicitation unnecessary at the time the identification is attempted, a potentially time-consuming endeavor that may cause further distress to the victim's family.

Unlike the NCIC, non-dental variables are not incorporated into the F.I.N.D. search routine. As discussed above, the NCIC has demonstrated that the system's accuracy is diminished by such visual characteristics as birthmarks, eye color, etc. due to their apparent subjectivity and because these kinds of properties may be lost as decomposition progresses. For this reason, such auxiliary criteria are instead assigned to the general information component of F.I.N.D., and can be utilized once the search via dental data has identified the most likely matches.

The system requires only minimal prior knowledge and experience with computers, since program options are made simple and convenient by icons displayed on the screen. Help menus are on hand to guide the user through each step of creating a profile or performing a search and because most data entry functions are "point and click," requiring only mouse operation, the user is obliged to conform to the standards predetermined by the program.

The only aspect of F.I.N.D. that requires keyboard entry is the generic "missing person" data as outlined above, which does not have bearing on the program's search provision. Thus, spelling errors or misinformation regarding the child's physical description or the circumstances surrounding the disappearance will not affect the search results in any way.

Measures have also been included to prevent unauthorized access to F.I.N.D. in the form of a built-in security feature. This access-control encryption device verifies the identity of the user and limits privileges to view and alter files. Before access is attained, the user is obliged to enter an ID number and password that are checked against an index stored in the computer. Passwords may contain a mixture of characters and symbols and so do not necessarily represent real words. They can be modified periodically, making the encrypted information difficult to forge or decode. To further prohibit unauthorized access, the number of attempts to enter a correct password can be limited to a specified number. Finally, the program

automatically maintains a running log of all activity, so that all data entered, modifications made to existing data, or executed searches, can be traced back to the user.

V. LIMITATIONS

As with most computer applications, the success of F.I.N.D. is contingent upon a number of ancillary factors. For example, although precision is not imperative to successful use of the program, meticulous care should be demonstrated when entering dental data. Accuracy will enhance search efficiency by reducing the number of possible matches that may otherwise be broadened by the inclusion of erroneous data.

Successful implementation also requires the cooperation of next of kin and pertinent dental healthcare practitioners in providing the necessary clinical dental records and supporting radiographic materials. Moreover, while neither tooth restorations nor radiographs are imperative to creating a missing person profile or performing a postmortem search, the success of F.I.N.D. is based on the assumption that clinical dental records exist prior to the child's disappearance. Lack of such records makes use of the system untenable.

VI. SYSTEM REQUIREMENTS

A working archetype of F.I.N.D., which has been developed for demonstration purposes, was written in Microsoft Access 97 using Microsoft Visual Basic. Available on CD-ROM, it will run on any IBM-compatible computer (Pentium or higher), and requires the Microsoft Windows 95 or 98 operating system and Microsoft Access 97. A high-resolution drum or flat bed scanner is recommended for downloading both photographs and dental X-rays. In addition, a transparency-adapted printer is best suited for reproducing materials used for comparison purposes.

* * *

VII. CREATING A PROFILE OR CONDUCTING A SEARCH

The opening screen (Figure 1) prompts the user to choose from one of the following options:

- ***Enter Profile Data*** (for creating a Missing Person Profile).
- ***Modify Profile Data*** (for making any necessary changes to existing data or for deleting an obsolete profile).
- ***Look Up Profile*** (When a profile has been identified as a possible match).
- ***Search Database*** (for postmortem comparison purposes).

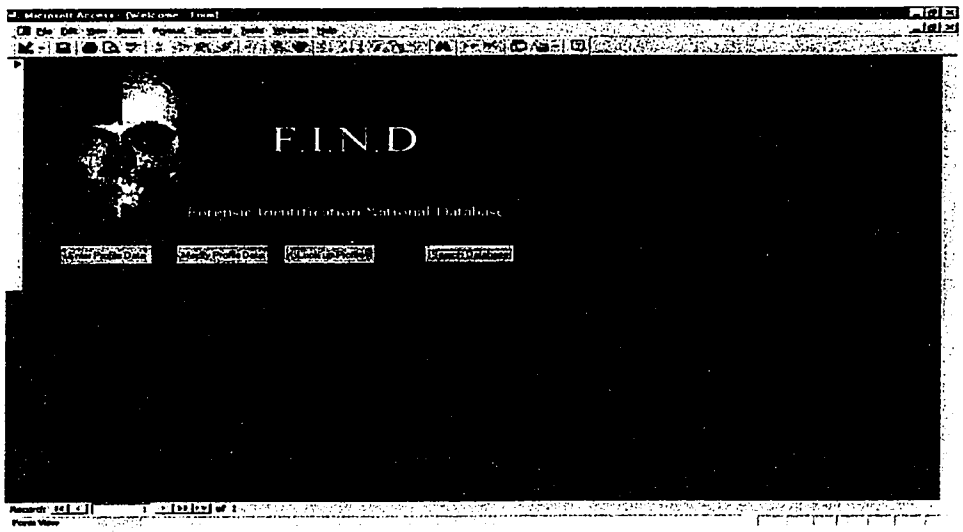

Fig. 1: The user can elect to create a new profile, modify existing data, or perform a search of all electronically stored dental records.

Providing written dental records are obtained, it is not necessary to be trained or have experience in dentistry to use F.I.N.D. The program is designed to be "user friendly," so only minimal hands-on instruction is required.

VIII. CREATING A MISSING PERSON PROFILE

Clicking on ***Enter Profile Data*** will bring up the next screen (Figure 2).

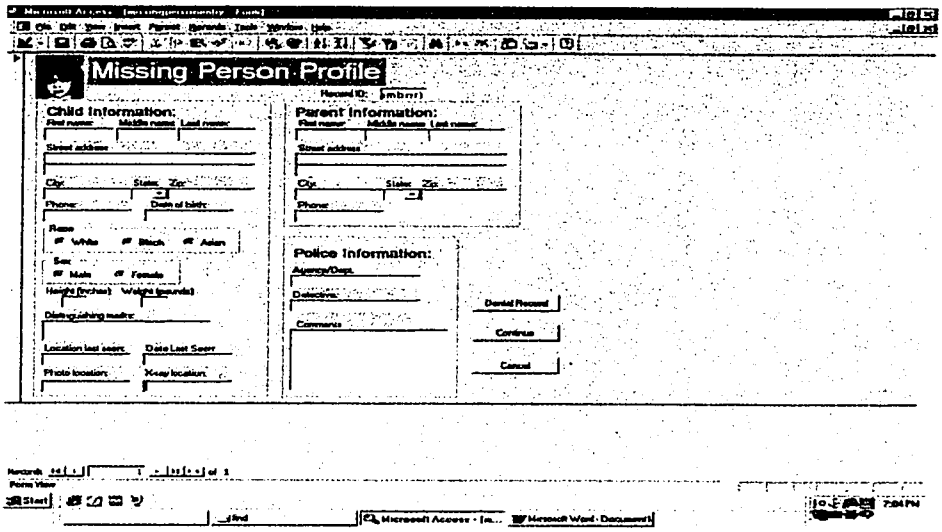

Fig. 2: The information requirements in this screen are not a component of the search routine. Therefore, data entry errors will not compromise the program's search efficiency.

Missing Person Profile: The user completes the information as listed. With one small exception within the postmortem dental input screen, this is the only area of the database that requires keyboard input, since the missing

person information does not influence the search. Thus, spelling errors or misinformation will not compromise the search in any way.

It is at this time that a jpg file containing dental X-rays and a current photograph of the missing child can be attached to the profile. It should be noted that the name of the missing person and the profile ID number are automatically maintained on all subsequent screens.

Click on ***Continue*** to advance to the next screen (Figure 3).

IX. CONSIGNING DENTAL DATA

The next step requires the dental information of the missing person to be added to the profile, and this must be consistent with the child's most recent clinical records.

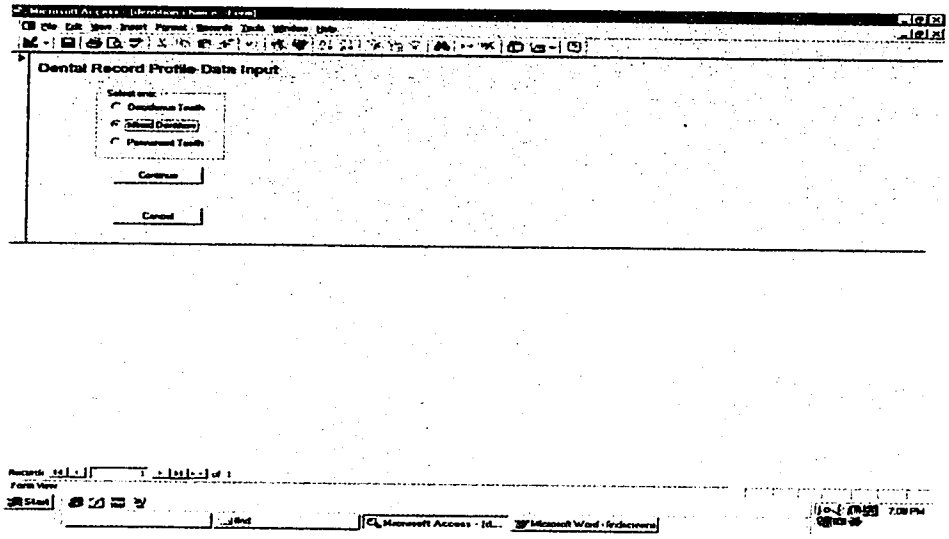

Fig. 3: Dental Record Profile Data Input screen.

The user clicks on one of the three dental options: ***Deciduous Teeth***, ***Mixed Dentition***, or ***Permanent Teeth*** followed by ***Continue.***

F.I.N.D. will then automatically advance to the ***Missing Person Dental Information*** input screen (Figure 4).

The user adds information relating to a tooth by first clicking on one of four options as applicable: ***Unfilled, Unerupted, Missing,*** or ***Filled.*** For instance, if Tooth 1 (Upper Right 3rd Molar) is unerupted, unfilled, or missing, the user clicks on one of these choices, followed by ***Add Record***, and the

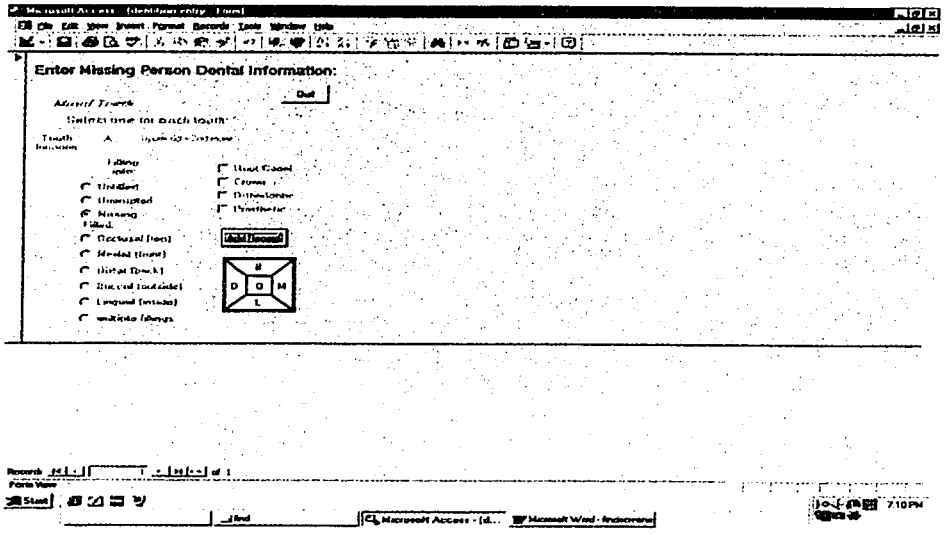

Fig. 4: Missing Person Dental Imput screen. Deciduous teeth are designated A-T, while Permanent teeth are assigned with a number, 1-32.

program moves on to Tooth 2 (Upper Right 2nd Molar), where the procedure is repeated. Conversely, should Tooth 1 contain a restoration, the user would

click on one or more of the designated tooth surfaces that correspond with the filling location.

At this point the user must add the location/type of any restoration as applicable. Hence, if Tooth 1 has a filling on both the mesial and occlusal surfaces, the user could either elect to click on the icons designated ***Mesial*** and ***Occlusal***, or on the ***Multiple Fillings*** option (if the filling location is in any way ambiguous). The schematic diagram on the right illustrates the tooth surfaces for easy reference and is also interactive, so it can be used to select the restored tooth surface instead of the adjacent icons.

This is repeated for all subsequent teeth. The dental field requirements are contingent upon whether the dentition is deciduous, permanent, or a combination of both. For example, there are a total of twenty deciduous teeth and each is assigned with a letter (A through T). Permanent teeth, thirty-two in total, are designated with a number (1 through 32). Since mixed dentition consists of both deciduous and permanent teeth, information is required for a total of fifty-two dental fields, A through T and 1 through 32, respectively. The mixed dentition dental data takes a little more time to complete but is the most representative of children between the ages of six and 12 years.

Once the dental information has been added, the user can view the completed record and validate its accuracy by clicking on the ***Dental Record*** icon (see Figure 5 on the following page).

This completes the *Missing Person Profile.* Please note that all data having influence on the search routine is "point and click," obligating the user to conform to the standards predetermined by the program.

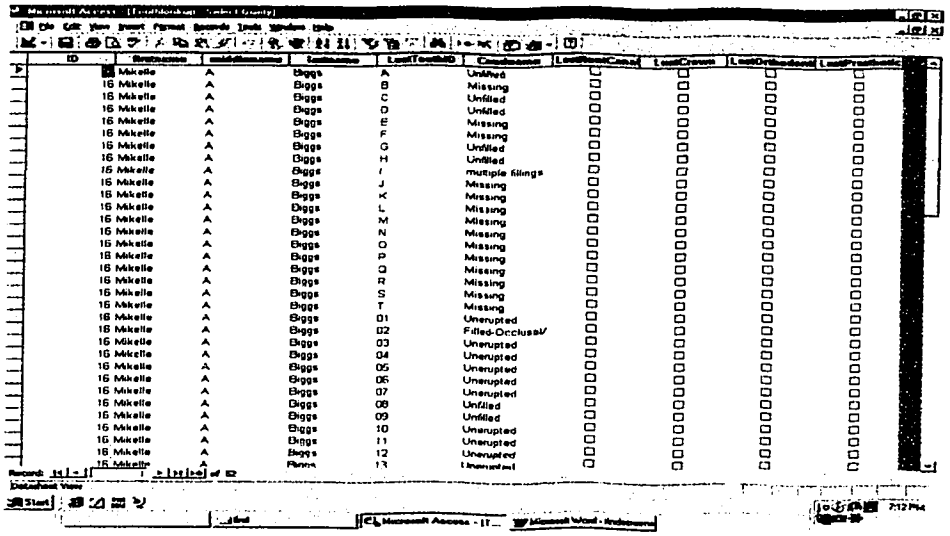

Fig. 5: The full dental record can be in viewed by clicking on the ***Dental Record*** icon.

X. POSTMORTEM SEARCH CRITERIA

The database search is carried out by the end user: the forensic odontologist, forensic anthropologist, or other appropriate specialist. When decomposed or skeletal remains are recovered, F.I.N.D. can be used in an attempt to match postmortem dental data with the program's electronically stored missing person profiles.

The initial step of a postmortem search is the same as when creating a missing person profile, except it is now necessary to click on the option

marked ***Search Database***, located on the program's opening screen. This will automatically take the user to the ***Enter Postmortem Dental Data*** screen (Figure 6).

Adding postmortem dental information is the same as when adding antemortem dental data as outlined on pages 21-22. However, here the number or letter representing the tooth is not automatically maintained by the program and must instead be typed in the window designated ***Tooth Location*** (this keyboard entry function is not case sensitive). Therefore, if a

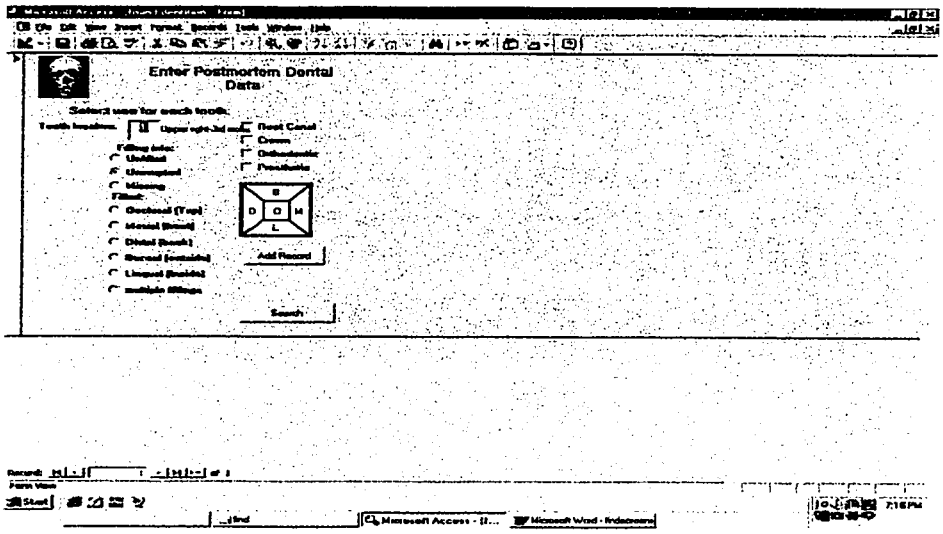

Fig. 6: Entering postmortem dental data is the same as entering Missing Person dental data, however, now the user must type in the corresponding tooth number or letter.

partial dentition is recovered, it is only necessary to enter information for teeth that are present. Obviously, the fewer the number of teeth used in the search, the greater the number of possible matches the program will identify.

Once the data are entered, the user then clicks on the ***Search*** icon located at the foot of the dental input screen, prompting a search of all electronically stored *Missing Person Profiles*.

XI. POSTMORTEM SEARCH RESULTS

The proceeding screen automatically displays all possible matching records, from the most highly correlated match to the lowest, in descending order. The first column registers the number of corresponding dental attributes and the second column the *Missing Person Profile ID Number* (Figure 7).

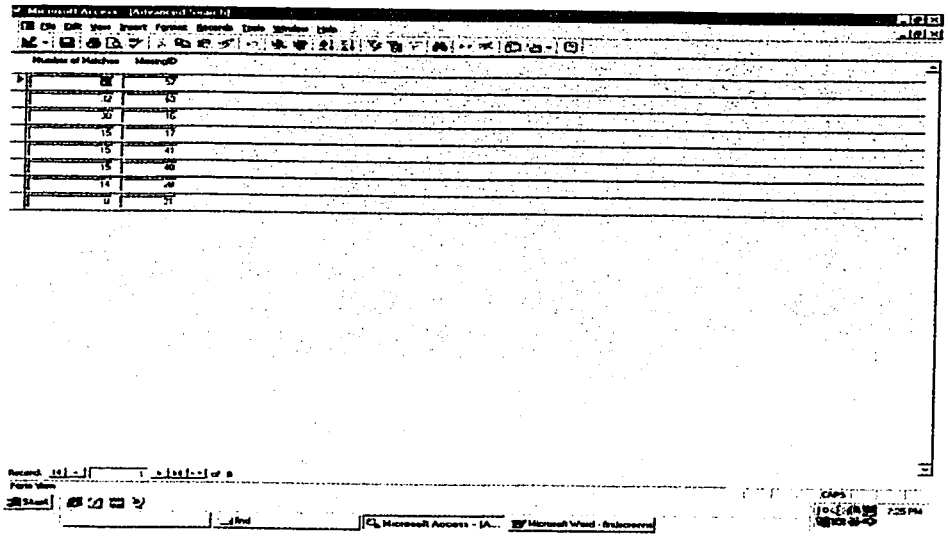

Fig. 7: Potential matches are displayed with the highest correlated match appearing at the top.

Clicking the cursor in the window containing the ID number will prompt the corresponding profile to appear on the screen. If the most highly correlated match does not compare favorably with the postmortem record, the user then moves to the next profile on the screen, and so on.

If and when a match between ante- and postmortem dental records appears likely, the user can choose to enlarge both the attached photograph and X-ray by clicking on the images at the top of the Missing Person Profile screen.

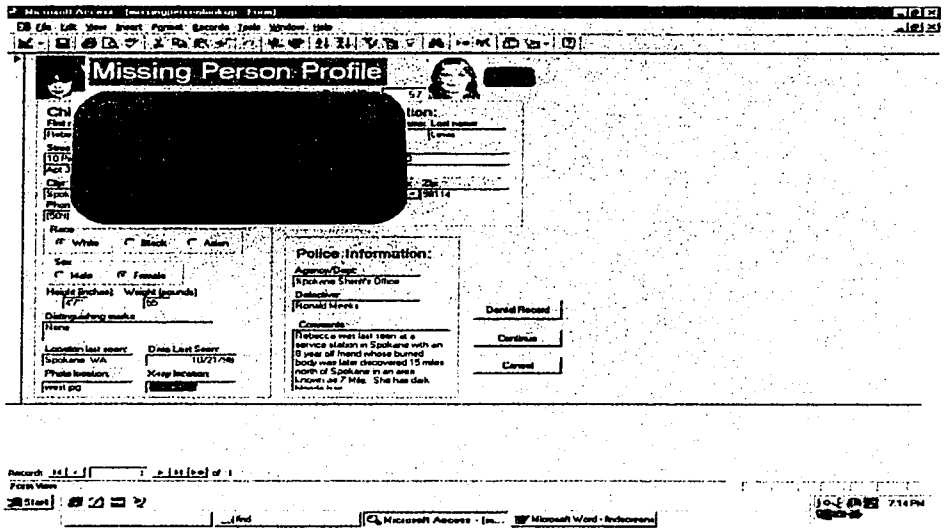

Fig. 8: Both the attached photograph and dental X-ray can be enlarged (as depicted above) by clicking on the pertinent jpg file at the top of the screen.

Figure 8 depicts the dental radiograph in expanded form. Printed onto a transparency, the attached clinical radiographs can be compared with similar postmortem X-rays, thereby hastening the identification process.

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