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TECHNICAL NOTE

Michael J. Thali,[1,2] M.D.; Thomas Markwalder,[1] D.D.S.; Christian Jackowski,[1] M.D.; Martin Sonnenschein,[2,3] M.D.; and Richard Dirnhofer,[1] M.D.

Dental CT Imaging as a Screening Tool for Dental Profiling: Advantages and Limitations

ABSTRACT: The use of dental processing software for computed tomography (CT) data (Dentascan) is described on postmortem (pm) CT data for the purpose of pm identification. The software allows reconstructing reformatted images comparable to conventional panoramic dental radiographs by defining a curved reconstruction line along the teeth on oblique images. Three corpses that have been scanned within the virtopsy project were used to test the software for the purpose of dental identification. In every case, dental panoramic images could be reconstructed and compared to antemortem radiographs. The images showed the basic component of teeth (enamel, dentin, and pulp), the anatomic structure of the alveolar bone, missing or unerupted teeth as well as restorations of the teeth that could be used for identification. When streak artifacts due to metal-containing dental work reduced image quality, it was still necessary to perform pm conventional radiographs for comparison of the detailed shape of the restoration. Dental identification or a dental profiling seems to become possible in a noninvasive manner using the Dentascan software.

KEYWORDS: forensic science, forensic radiology, dental identification, Dentascan, computed tomography

Radiology plays an important role in forensic identification (1). Radiological identification, most typically by the use of dental radiography, is based on the comparison of antemortem (am) and postmortem (pm) images and is often a valuable alternative to fingerprinting and DNA identification. Of course, individual radiological characteristics can allow positive identification only if am radiographs exist for comparison. In mass casualty situations with, e.g., charred bodies with only calcified bones left, radiographic comparison is often the only viable way when classical identification methods prove futile (2–4). Dental identification uses the teeth, jaws, and orofacial characteristics in general as well as the specific features of dental work with metallic or composite fillings, crowns, bridges, and removable prostheses as well as distinctive configuration of bony structures of the jaw (mandible and maxilla), the presence and shape of teeth including the roots, the configuration of maxillary sinuses, and longstanding pathology, such as prior fractures and orthopedic procedures (5–9).

So it is not surprising that the Armed Forces Medical Examiner at the Armed Forces Institute of Pathology in Washington, DC/Rockville, MD, use radiology as a standard method. Modern dental identification teams are increasingly using computer assisted dental identification software. For example, the newest WinID software (10) includes a graphic interface (6). By using portable dental x-ray units, such as the Min-X-ray (11), it is today even possible to acquire the dental data in a digital form at the scene of a mass casualty.

Classical methods for forensic dental identification are the clinically used radiological documentation techniques such as dental periapical radiographs, bitewing films, and panoramic tomographs (OPTs). A novel method in dentism is computed tomography (CT) of the teeth.

Until some years ago, radiographic imaging using the classic axial and coronal CT views of the mandible and maxilla was difficult because of superimposition of dense teeth and dental streak artifacts from dental restoration. Newer dental CT reformation software allows reformatting axial images to multiple panoramic and periapical views.

In this study, we evaluated for the first time this newer CT imaging-based software called Dentascan (Siemens Medical, Erlangen, Germany) for identification purposes. Until recently, the Dentascan programs were used in the clinical environment to evaluate dental implants, assess tumors, cysts, inflammatory diseases, fractures, and surgical procedures (8). The objective of this article is to demonstrate, with a series of examples out of the Virtopsy project (12), what are the applications, advantages, and limitations of this Dentascan method for dental profiling purposes.

Materials and Methods

Recently, we discussed in a feasibility study the possibilities of pm CT (and MRI) scanning in forensic medicine (12). Within the Virtopsy project, more than 100 forensic cases were scanned between 2001 and 2004 using Multislice CT. MSCT scanning was so far performed on a multislice CT scanner system with a collimation of 1.25 mm and slice thickness 1.25 mm. CT scanning time ranged around 10 min.

[1] Institute of Forensic Medicine, University of Bern, CH-3012 Bern, Switzerland.
[2] Institute of Diagnostic Radiology, Inselspital, University of Bern, CH-3010 Bern, Switzerland.
[3] Department of Diagnostic Radiology, Sonnenhof Spital AG, CH-3006 Bern, Switzerland.

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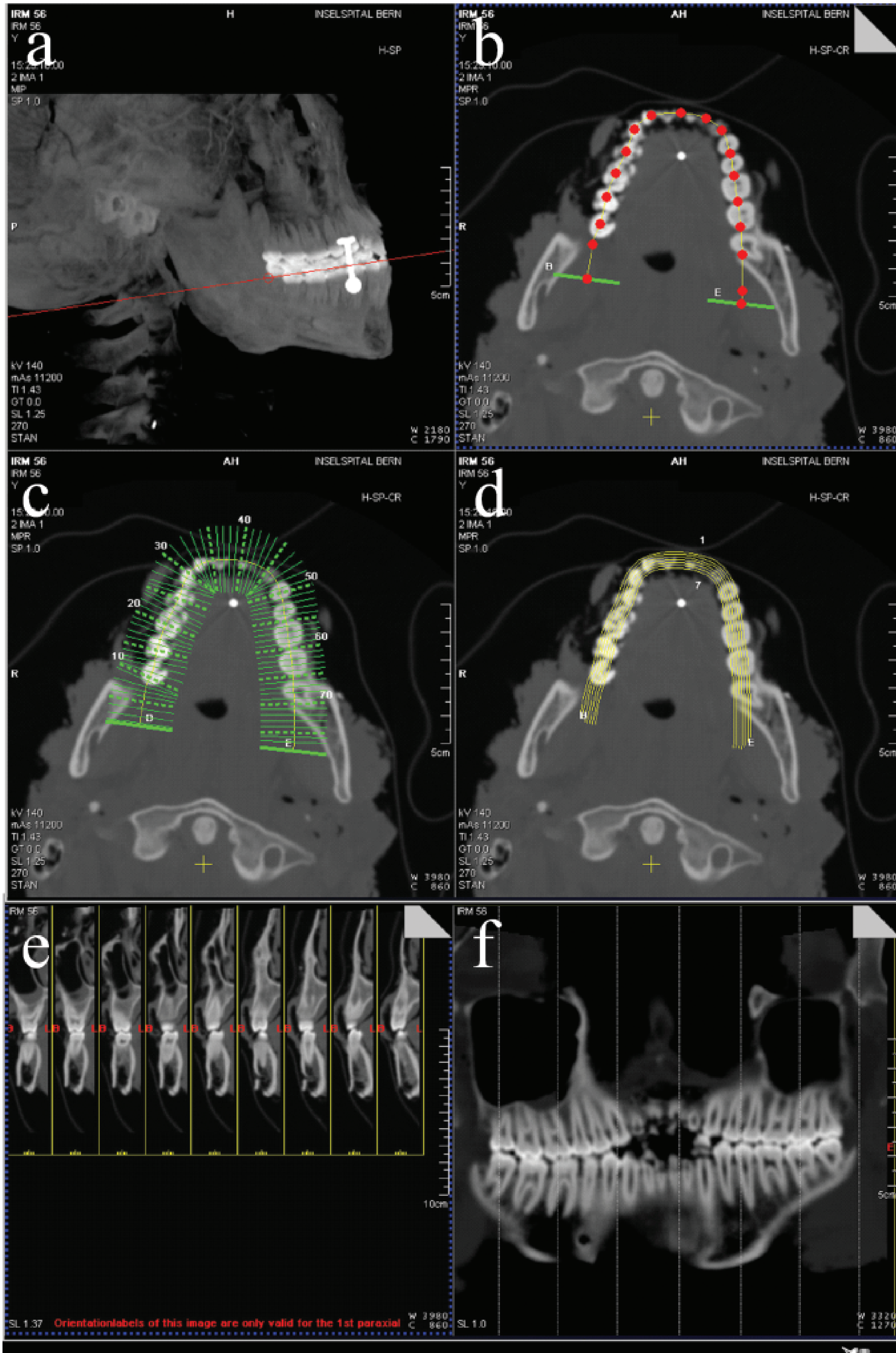

FIG. 1—*Workflow using the Dentascan processing software. (a) On a lateral view of a 3-D transparent bone reconstruction of the skull, a level for an oblique section (b) is to be defined, that allows to appoint the centers of each tooth. Note an additional tongue piercing. (b) On the oblique cross section through the level of the teeth, the position of the teeth is manually defined by placing points on the image and thereby defining a curved reconstruction line. (c) Along that line, paraxial dental cross sections in a user-defined number and thickness are placed. (d) Parallel to the curved reconstruction line, up to 6 additional panoramic dental reconstructions in a slice thickness between 1 and 20 mm can be created covering the teeth from lingual to buccal. (e) Several paraxial cross sections are exemplarily demonstrated. (f) Shown is one of the 7 created thin (1 mm) panoramic dental reconstructions that allows for a comparison with antemortem dental radiographs.*

Multiple panoramic and cross-sectional views were built from the axial data set of the spiral CT data at a separate workstation (Leonardo, Siemens Medical, Germany) using the Dentascan postprocessing software within a few minutes.

Within the Dentascan program, a curved line is produced by the user on an oblique cross section which direction was prior adapted to the jaw (Fig. 1*a*,*b*). This curved line defines the center of the teeth. Along this line, the software creates panoramic images in a user-defined thickness and number. Thereby it is possible to create a thick (e.g., 20 mm) panoramic reformatted image containing the information of the entire jaw comparable to a conventional radiograph image. Otherwise, multiple thin sections (e.g., 1 mm) from buccal to lingual can be created parallel to the defined line, which allow for a more detailed dental assessment (Fig. 1*d*,*f*). Then the program draws multiple-numbered lines perpendicular to this curved line. These lines define where the periapical images of single teeth will be reformatted (Fig 1*c*,*e*). The distances between the numbered cross sections as well as between the panoramic views can also be varied. For the thin sections, it is advisable to do so separately for the upper and lower jaw as especially the overbite of the front teeth will prevent a tight fitting of both entire jaws into one curved line.

To demonstrate the method, three charred or putrefied bodies out of the more than 100 Virtopsy cases are shown. In each case, there were am dental radiographs available comprising regular and panographic films. In each case, a pm Dentascan was produced from the axial CT data set of the jaw.

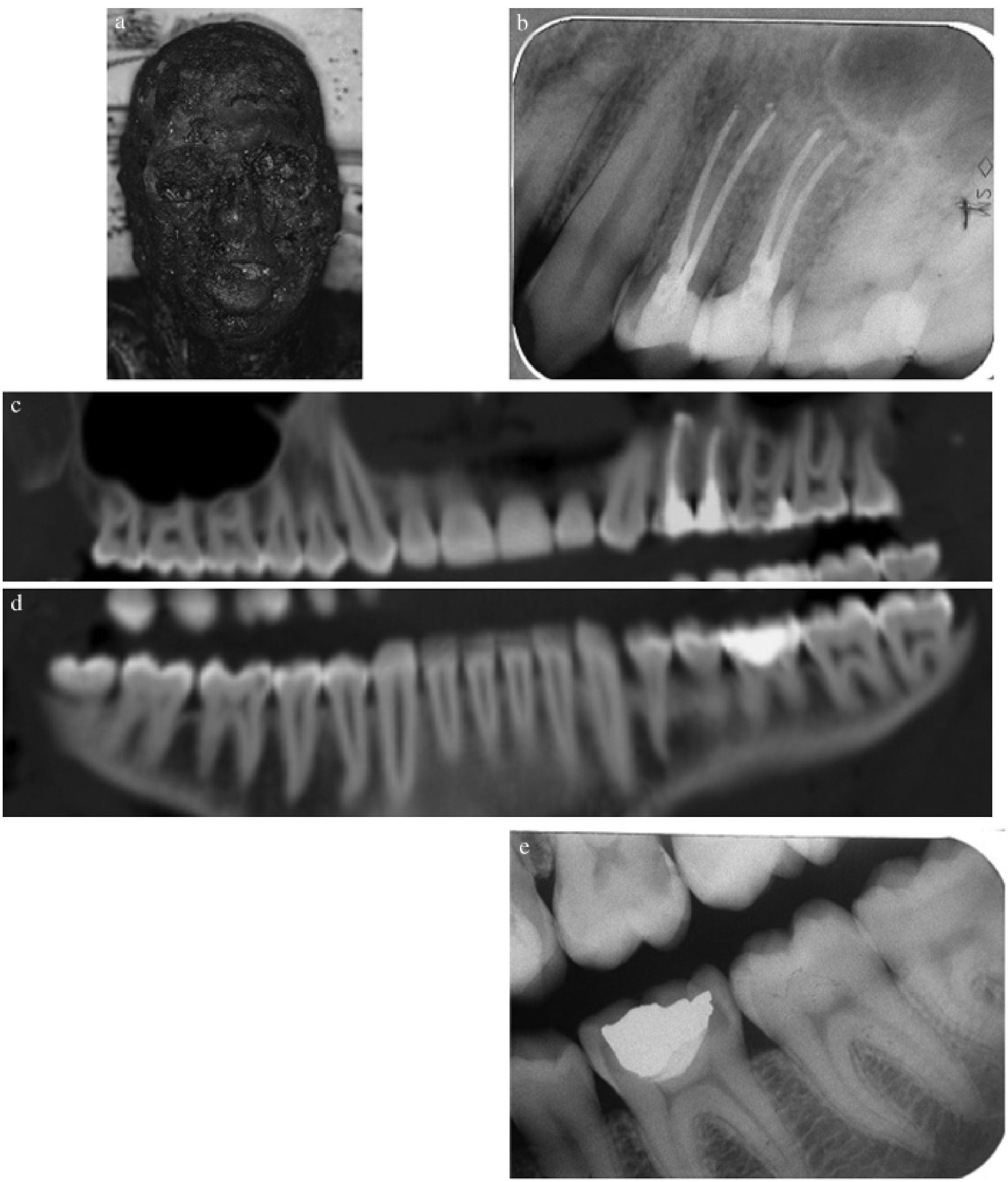

FIG. 2—*Case IRM 004. (a) A burned victim of a vehicle accident. (b) Antemortem upper left bitewing radiograph. (c) Postmortem upper jaw panoramic reconstruction. (d) Postmortem lower jaw panoramic reconstruction. (e) Antemortem lower left bitewing radiograph.*

Results

Using the Dentascan software, reformatted panoramic images could be reconstructed for each case that were compared to the am dental periapical radiographs, bitewing films, and panoramic radiograph.

As seen in Figs. 2–4, the comparison of am data and pm dentascan panoramic images shows unique features for the identification of the deceased. These thin sections (1 mm) show composite fillings even if they reached deeply into the root (Fig. 2). Extensive dental work still decreased the image quality due to streak artifacts within the original axial CT data. But the comparison of am and pm data still allowed for a positive identification when additional characteristics such as missing 36 and 46 were present (Fig. 3). The third case presented without a complete dentition (Fig. 4). Owing to the heat predominantly the frontal teeth were missing or partly destroyed. The Dentascan was strongly indicative for the assumed person, but identification was not positive until conventional pm radiographs were taken on the dissected jaw for comparison (Fig. 5).

Discussion

The objective of using radiographs in identification is to compare and evaluate similarities and relevant features (those which are stable and distinctive) as well accounting for discrepancies and assessing the uniqueness and finally verbalizing the degree of confidence in the identification. As previously reported, pm CT scanning can be of great help in managing mass disasters scenarios (2). Specific and unique radiological features of the jaw and the body can be used for identification purposes by comparing am and pm data. Using pm CT is fast and because of the noninvasiveness, a great help in the no-touch documentation of fragile and brittle teeth in carbonized bodies.

A reformatted panoramic overview created by Dentascan delivers in a noninvasive way to overview the jaws showing the basic components of teeth (enamel, dentin, and pulp), the anatomic structure of the alveolar bone (with mandibular and maxillary landmarks such as, e.g., mandibular nerve canal or the floor of the nasal cavity and the maxillary sinuses), pathology (caries, radiolucencies, radiopacities, or position of third molars), and restorations.

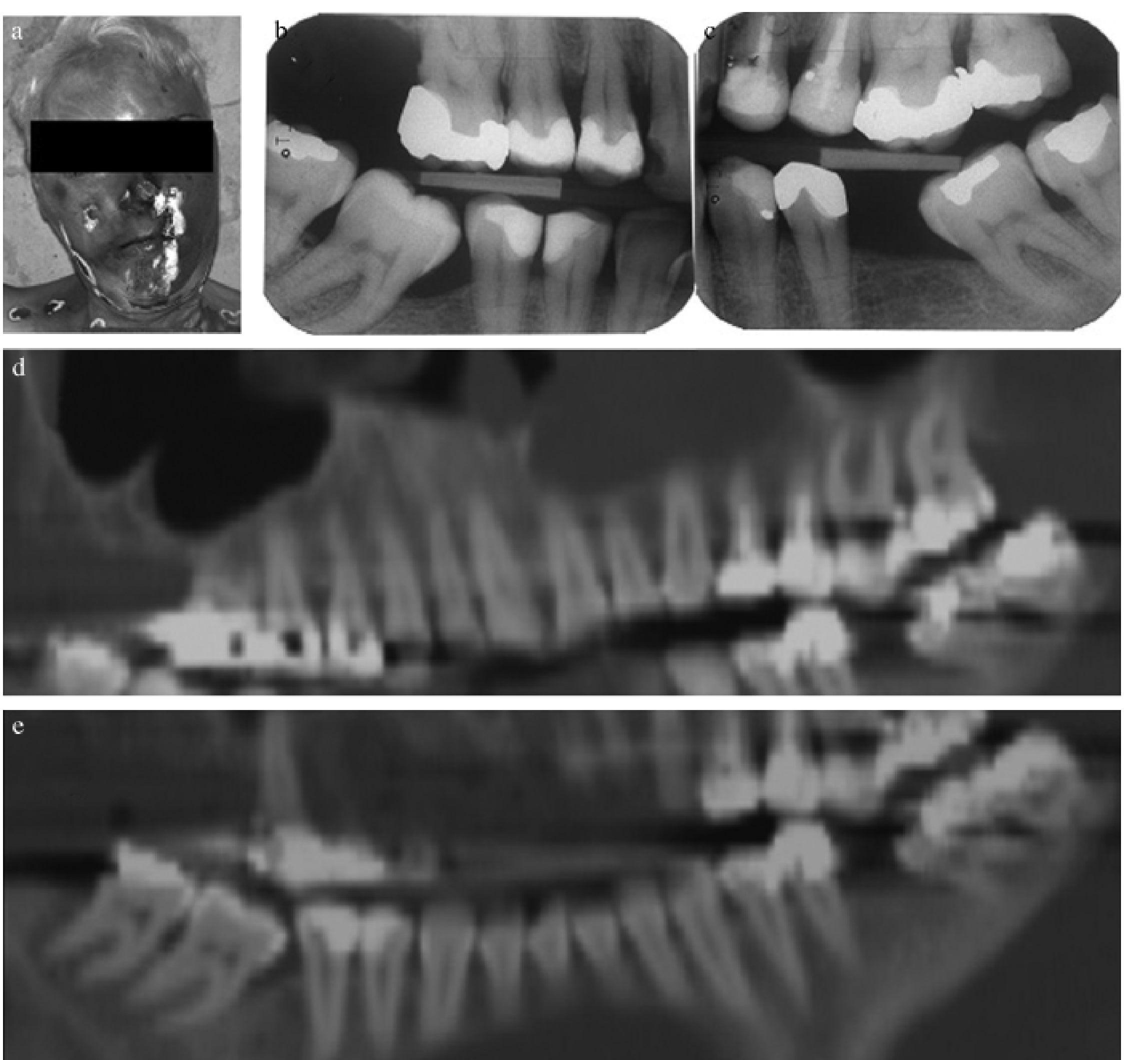

FIG. 3—*Case IRM 062. (a) A corpse found in an advanced stage of putrefaction. (b) Antemortem right bitewing radiograph. (c) Antemortem left bitewing radiograph. (d) Postmortem upper jaw panoramic reconstruction. (e) Postmortem lower jaw panoramic reconstruction. Note streak artifacts within the panoramic reconstruction due to plenty of metallic restoration that decreases the visibility of some individual restorations. But the additional characteristic teeth position of the lower bitewings allows for a positive identification.*

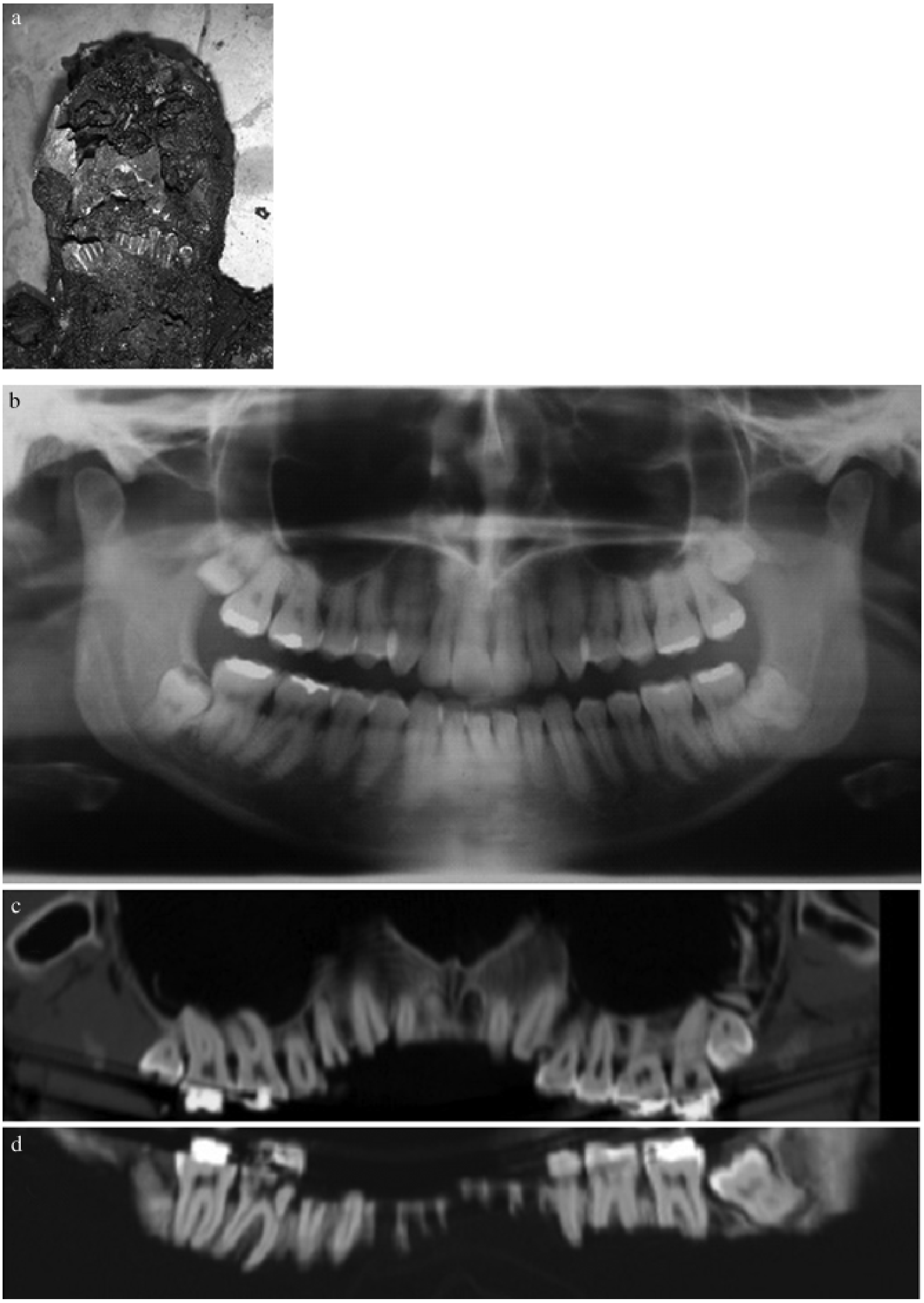

FIG. 4—*Case IRM 058. (a) A burned victim of an air plane crash. (b) Antemortem orthopantogram. (c) Postmortem upper jaw panoramic reconstruction. (d) Postmortem lower jaw panoramic reconstruction. Note the severe destruction of predominantly the frontal teeth. Comparison of the remaining teeth and position of the third molars are indicative but not evident for identification.*

The Dentascan examination method is already clinically used and is an additional examination and documentation tool as a supplement to periapicals, bitewing films, and classic panoramic radiographs in dentistry (13,14). Similar to the panoramic OPT, where the jaws are rendered flat by having the film and beam simultaneously rotating around the head during the exposure, the Dentascan shows the entire U-shaped maxilla and mandible flattened out on one image.

The most important advantage of Dentascan in contrast to classical methods is that the documentation can be made in a non-invasive and digital way without jaw resection, which is often performed to facilitate classical radiological documentation on

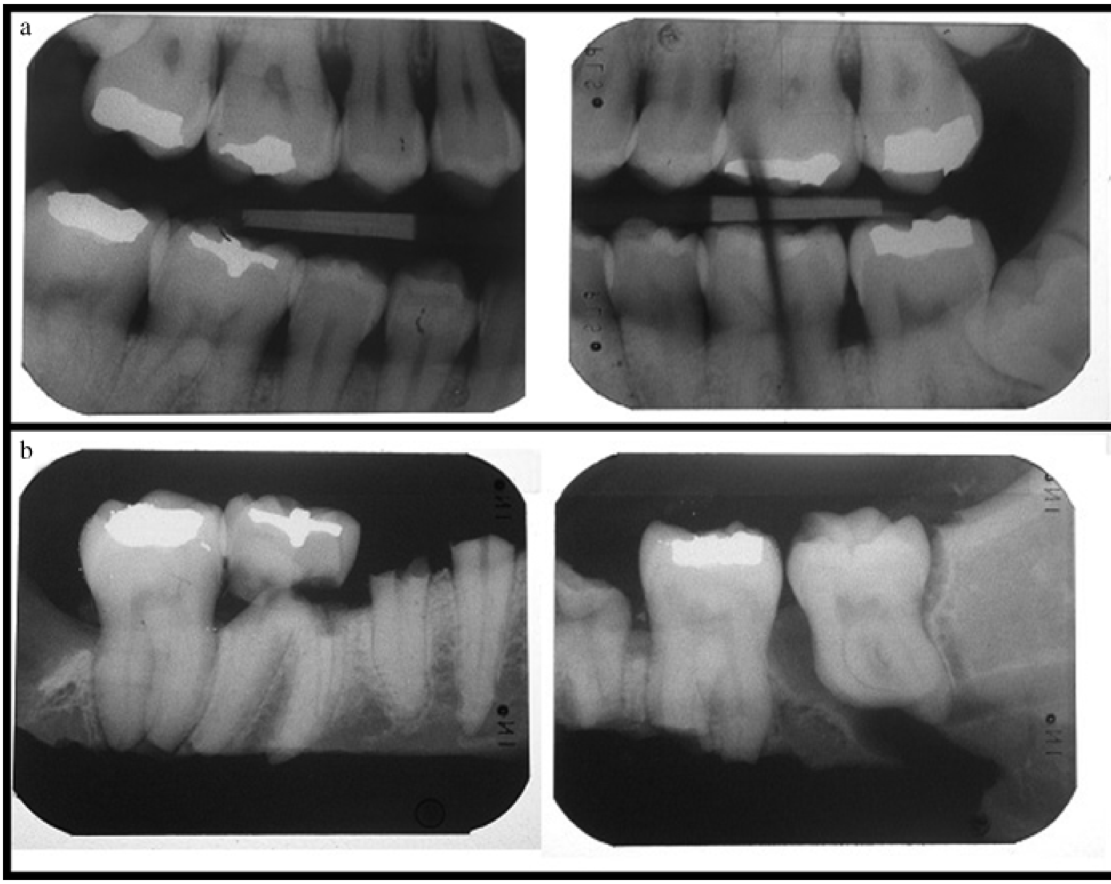

FIG. 5—*Case IRM 058. (a) Antemortem bitewing radiographs. (b) Postmortem lower bitewing radiographs. The detailed comparison of the shape of the dental restorations to postmortem radiographs allows for a positive identification.*

decomposed, charred, and mutilated corpses. There is no need for special positioning techniques (rubber bands or density substitutes for missing tissue, if the samples are macerated because of odor effects) like they are used to produce pm periapical, bitewing films, and classic panoramic radiographs (9) because the Dentascan is an *in situ* documentation method. A further advantage of the *in situ* documentation process is that there is no secondary damage, which is often a problem, e.g., in charred bodies. The data can be stored directly on the hard disc or a CD, and a transfer through the Internet or the export in a modern graphic dental identification program (e.g., WinID) (10) is easily possible. Beside the unlimited data storage, every desired 2-D/3-D reconstruction is possible.

The Dentascan—as shown in the examples—allows for a comparison with the am information and finally the identification necessary information like number and arrangement of teeth, caries and bone structure (trabecular bone pattern, nutrient canals, bony landmarks, sinuses), and even the restorations are visible. The presented cases have retrospectively been chosen from the Virtopsy project. As these data have been acquired using a collimation of 1.25 mm to cover the whole corpse, there is still an increase of image quality possible, when future Dentascans can be reconstructed based on a specifically collimated raw data acquisition adapted to the desired dental investigation such as a collimation of 0.5 mm resulting in isotropic voxels and an increased increment.

Unfortunately, it is precisely the dental restorations, which cause streak artifacts in MSCT due to their increased radiopacity, which could not totally be eliminated even through the reformatting process. So, when extensive dental work is present, the detailed documentation of the shape of the restorations is less precise than when compared to a classical radiograph. To solve the problem of metal-induced streak artifacts in CT is a topic of extensive recent research efforts (15). Otherwise, removable prosthesis or removable partial denture can be removed for a second raw data acquisition.

Furthermore, in the near future, the am documentation in the form of Dentascan documentation will gain an increasing role and might replace the classic panoramic radiograph. In addition, there are less metallic restorations necessary in younger people today and restorations will more often consist of more radiolucent nonmetallic composite material (16), thus further decreasing the influence of metallic artifacts on image quality. In the future, it is expected that dental identification will rely more on bone structure than on restorations.

Lastly, the possibility to rearrange bony and dental fragments in comminuted fractures of the jaw within a 3-D model of the dental CT data needs to be mentioned as it allows for a better comparison with am radiographs of the unfractured jaws (17).

Conclusion

In conclusion, dental identification or profiling will often be possible by exclusively using the Dentascan overview documentation. If the identification requires more detailed information concerning the shape of a restoration, it is still possible to remove some teeth to make a comparison based on pm periapical or bitewing radiographs.

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Additional information and reprint requests:
Michael J. Thali, M.D.
Institute of Forensic Medicine
University of Bern
Buehlstrasse 20
CH-3012, Bern
Switzerland
E-mail: michael.thali@irm.unibe.ch