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**A Novel Forensic Use of Clinical
Odontological Imaging: Geometric Morphometric Analysis of Sexual Dimorphism in the Mandible
From Panoramic Scanning X-Ray Images**

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This presentation will impact the forensic science community by exploring a photographic technique that provides a reliable system for use in the field or laboratory. It is currently being tested within the Forensic Science Institute of the French Gendarmerie (I.R.C.G.N.). The practical applications presented can be used as a guideline available to forensic odontologists.

Photography is an important element of dental forensic examination. It is often required by magistrates and investigators because pictures are able to show the mandibular and the maxillary teeth, their characteristics, their pathologies, and dental treatments.

Materials and methods: The digital SLR camera with a 60 mm lens is mounted on a stand equipped with a light source. This device is coupled to a laptop computer equipped with a distance shooting software package. A mouse is activated with the foot. This provides a means of capturing an image. The operator takes the photo hands-free and frames by visualizing on the screen.

Results: The testing environment enabled the identification of some key points.

Automation: On the camera the function, AF coupled with the function S treats the sharpness of the image. Thus, for each shot, the auto focus and sharpness is achieved without any manual intervention from the operator.

Handling: Holding the object to be photographed in their hands, the operator chooses easily the exact plane of the desired image.

Ergonomics: There is no need to use two operators, a clean hand operator and a dirty hand operator, or to continually change gloves between dirty and clean interventions. An operator can easily work alone.

Framing: Direct vision on the screen enables the observation of a greatly enlarged scale image. Details can be highlighted.

Speed: The reduced need for focusing decreases the time taken considerably.

Repeatability: The foot control of the camera permits the repeated shots with ease.

Cleanliness: The issue of the cleanliness of the collection of images and contamination of the photographic material is resolved because at no point does the operator touch the equipment.

Flexibility: The final results can be verified immediately on the screen and the ability to correct mistakes is possible – simply by acquiring another image.

Discussion: The use of photographic equipment and shooting a predetermined four orientations can establish a standardized photographic record.

Thus for each mandible and maxilla an occlusal view, buccal anterior view and two lateral views are taken. Photographs of specific details are made if necessary. A photographic record for each victim is always produced and it contains all the photographs of the case.

When producing a report, the photographs of the occlusal surfaces are preferably framed and each tooth is identified according to the classifications used in countries where the expertise is conducted (FDI nomenclature, Universal system; Army system...).

Other photographs (front view, left and right side views, and photographs of details) are subject to a layout on a specific page.

The entire photographic record illustrates the dental status of the victim. It will support the comparison, along with radiographs and antemortem records.

Conclusion: A question emerges from this presentation – if sound photographic records can be produced – is a pictorial odontogram required?
Odontology, Photographic Technique, Computer

F16 A Novel Forensic Use of Clinical Odontological Imaging: Geometric Morphometric Analysis of Sexual Dimorphism in the Mandible From Panoramic Scanning X-Ray Images

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After attending this presentation, attendees will have a better understanding of the sex determination during the skull assessment.

This presentation will impact the forensic science community by introducing a novel method of sex determination in the process of human identification investigations.

The human mandible is routinely utilized as part of sex assessment in forensic odontological and anthropological practice. Various studies have pointed to the utility of morphological and metrical traits in the mandible, such as symphyseal shape, gonial angle and eversion, and ramus flexure among others in the assessment of biological sex. The research here presented utilizes geometric morphometric techniques to investigate and quantify shape and size variation in the morphology of the mandibular corpus and ascending ramus, and consequently highlights the potential for forensic human identification. The results of a novel morphometric study are presented using clinical panoramic scanning x-radiography, the goal of which was to develop a methodologically and statistically robust means of investigating biological variation in lower jaw morphology from a commonly acquired clinical data source.

As part of proof-of-concept, clinical digital orthopantomogram images (OPG's) were acquired from 50 male and 50 female adult participants from a modern Italian sample population. Ten type I and type II landmarks were applied to the symphyseal region and the condylar and coronoid processes of the resulting 2D images in order to anchor a framework of semi-landmark curves. One-hundred equidistant semi-landmarks were established along the inferior border of the corpus, and the posterior border of the ascending ramus, thus encompassing the symphyseal region, gonial region, and posterior ramus – all of which are isolated anatomical regions which have been demonstrated to exhibit significant expression of sexual dimorphism in previous studies. The resulting landmark and semi-landmark configurations were subjected to Generalized Procrustes Analysis (GPA) with Full Tangent Space Projection. Principal Component Analysis (PCA) was applied in order to assess populational variation. Factor loadings were subject to Canonical Variates Analysis with stepwise and leave-one-out classification in order to assess the effects of sexual dimorphism on mandibular shape. The preliminary results showed individuals to be correctly classified for sex in 89.6% of cases (males were correctly classified in 90.1% of cases, and females in 85.6%).

A partial least squares (2-block PLS) method was further applied, in order to examine patterns of covariation between shape variables and the exploration of patterns of functional modularity. In this case, functional modules are assumed to be units within which there is a high degree of integration from many and/or strong interactions, but which are relatively independent of other such units. The nature of the interactions can be, for instance, developmental, functional, or genetic, depending on the context. Most interestingly the results indicate the greatest level of individual and sex-specific variation is found in the shape-curve and pattern of the inferior corpus, in contrast to that of ramal flexure. However, a moderate degree of modular integration between the corporal and ramal regions suggests that functional ties between the units are correlated in influencing sex-based morphological trait expression. Consequently such units may be studied together or in isolation, and this may allow for the development of identification criteria based on modular unit shape variables which may be

applicable for both whole specimens and fragmented remains depending on the forensic situation. Overall, the results are strongly significant and suggest dependently and independently that the shape relationship between the mandibular corpus and the ascending ramus offers significant power for forensic identification purposes.

This investigation was designed to introduce a more standardized method of sex determination in the process of human identification within the field of forensic dental radiology. Orthopantomogram images allow an objective and reproducible 2D images reducing observer bias especially when the analysis of the mandible utilizes geometric morphometric techniques. This study confirms that the mandible exhibits significant sexual dimorphism and that skull assessment of unidentified cadavers cannot leave aside the odontological investigation with the benefit of stored radiological images. Nevertheless, further assessment on a wider sample of OPG's should be carried out in order to increase the predictive accuracy of this novel methodology.

Geometric Morphometrics, Sex Assessment, Forensic Odontology

F17 Comparing Cone-Beam CT With Conventional Digital Dental Imaging for Forensic Dental Identification

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After attending this presentation, attendees will gain knowledge of the use of cone beam CT in forensic identifications.

This presentation will impact the forensic science community by understanding how the use of cone beam CT derived images in forensic identifications is a viable time saving and a resource sparing technique.

Studies have previously presented evidence showing the ease of use of cone beam computed tomography (CBCT) derived images for dental identifications. The data gained from CBCT can be formatted into images that appear similar to periapical, bitewing, and panoramic radiographs. To further test the hypothesis that CBCT derived images are similar enough to conventional digital images to allow use in forensic identification, an IRB approved survey was developed.

The survey presented sets of images, each with a CBCT-derived periapical or bitewing image ("postmortem") as an unknown as well as five conventional radiographs (either bitewing or periapical, "antemortem") which may or may not be a "match" to the unknown, all on a one page sheet of paper. The five radiographs reviewed for each case are from the same anatomic location, but may be from a different individual; or taken from a different angle; or include fewer or more teeth; or be a bitewing instead of a periapical. The survey will be administered to multiple groups of dental practitioners, including dental students, post doctoral residents, practicing dentists and forensically trained dentists.

Five human jaw dissection specimens were scanned using an i-CAT cone-beam CT system and digital periapical and bitewing radiographs were taken of all dentate alveolar bone areas of the specimens. For each conventional radiograph, an image representing the same anatomical area was generated from the CBCT data set, as described previously. CBCT-derived images were cropped to the field of view of a conventional dental radiograph and to an aspect ratio of 4:3. CBCT-derived and conventional images of same anatomic areas of the specimens are presented in a survey alongside de-identified conventional radiographs of the same general region from patients with similar clinical dental situations (distracter images).

The results of the survey study will be presented and show the matching accuracy of the CBCT-derived image with the correct conventional image of the same specimen. In addition, each subgroup will be evaluated against the others to determine if the ability to correctly identify the "match" image with the unknown is a factor of years of experience in dentistry, experience as a forensic dentist or if a dental knowledge base is not required.

It is believed that CBCT derived images are similar enough to the conventional digital radiographs to allow their effective use in forensic identifications. Furthermore, it is believed that in situations such as mass disasters, the use of CBCT derived images would allow for rapid imaging of the deceased, allow reviewers to be located at a distance from the disaster site and allow for adjusting the viewing angle of the CBCT-derived ("postmortem") images to approximate that of the comparison ("antemortem") images.

Cone-Beam CT, Dental Identification, Radiographs

F18 Posthumous DNA Analysis Proves Equivocal Bitemark Analysis

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The goal of this presentation is to remind attendees that not all high-profile post-conviction DNA analyses result in exoneration of the convicted person.

This presentation will impact the forensic science community by serving as a cautionary tale by recalling the facts around a case where the bitemark and palm print evidence used to secure a conviction in a capital murder trial might be considered equivocal, but, ultimately, post-conviction and posthumous DNA analysis showed the conviction was not improper.

In July 1989, Jesse Joe Patrick broke into the home of a neighbor, 80-year-old Nina Rutherford Redd, through a bathroom window. Redd was sexually assaulted before having her throat slashed. Patrick ransacked the home before leaving and was later arrested in Mississippi. A blood-soaked sock was found in the home of Patrick. DNA matched the DNA in Redd's blood sample. Patrick's live-in girlfriend identified the knife found at the scene as theirs. Patrick confessed to the crime shortly after his arrest, but later recanted. Patrick had previously been convicted of aggravated assault in 1986 and sentenced to four years probation, which was later revoked.

Patrick was convicted of capital murder in the 282nd District Court of Dallas County and sentenced to death on April 16, 1990. His conviction and sentence were affirmed by the Texas Court of Criminal Appeals on June 28, 1995, and his petition for writ of certiorari was denied by the United States Supreme Court on March 25, 1996. Patrick also filed a state habeas corpus application, which the Court of Criminal Appeals denied on April 22, 1998.

Patrick then filed a federal habeas petition, which the district court denied on Aug. 23, 2000. After the district court disposed of several post-judgment motions filed by Patrick, he attempted to appeal to the United States Court of Appeals for the Fifth Circuit, but both the district court and the Fifth Circuit denied him a certificate of appealability to do so. He then filed a petition for writ of certiorari, which was denied by the Supreme Court on September 12, 2002. Patrick's motion for a stay of execution was also denied on Sept. 12, 2002.

In addition to his appeal and habeas corpus proceedings, Patrick filed a motion for DNA testing in the state trial court. Although sperm had been found on the victim, a DNA analysis had not been performed. Following a hearing, the trial court ruled that Patrick was not entitled to testing under Chapter 64 of the Texas Code of Criminal Procedure because there was no reasonable probability that favorable DNA results would have led to an acquittal—Patrick had not been charged with a sexual assault.

Since Patrick was willing to pay the costs of DNA testing, the court did rule he could have testing at his expense. The State appealed that ruling