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ORIGINAL ARTICLE

Sexual dimorphism of maxillary sinus using cone beam computed tomography

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Abstract: The aim of this study was to evaluate the sexual dimorphism of maxillary sinus dimensions using the CBCT imaging modality. Thirty CBCT scans of bilateral maxillary sinuses (60 maxillary sinuses) were retrospectively selected and the height, width, and depth of the sinuses were measured. All data were subjected to descriptive and discriminative functional analysis with generation of multiple logistic regression model and ROC analysis.

The overall values of the parameters were significantly greater in the males as compared to the females with the right height (90.0%) and the left height (83.3%) being the best predictors. This study proposes the importance of sexual dimorphism of maxillary sinus dimensions particularly the sinus height, when other methods used in the field of forensics seem to be indecisive. It suggests the use of CBCT in forensics thus obviating the complete dependence on the usage of conventional CT.

1. Introduction

Forensic personal identification by its inherent nature is a multidisciplinary team effort depending on positive identification methodologies as well as supposition or exclusionary approaches. However, typical identification methods may be indecisive, especially when certain extreme post-mortem alterations have occurred.[1] In spite of the leaps in medical breakthroughs, modern technology, investigations and its holistic application in forensics, identification of remnants of skeletal and decomposing parts of humans remains challenging. Forensic odontology aids personal identification through the processes of comparative dental identification, post mortem

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profiling from dental records, identification from dental DNA etc.[2]

Sexual dimorphism is one of its integral aspects as it is one of the initial steps in personal identification of an unknown cadaver thus narrowing down the diagnosis toward a correct possibility. Since, most bones that are conventionally used for sex determination (pelvis, skull & long bones etc.) are often recovered either in a fragmented, incomplete or commingled state especially in catastrophes like explosions, warfare, natural calamities, and other mass disasters like aircraft crashes, identification and sex determination are not easily achievable tasks.[3] It has thus become important to use denser bones that are often recovered intact, e.g. the maxillary sinus and thus alternate areas of the skeleton to be researched for sex estimation.[1] It has been reported that zygomatic bones and maxillary sinus remains intact although the skull and other bones may be badly disfigured in victims who are incinerated.[1,4] Maxillary sinuses are air spaces, located in the maxillary bone and can be in various sizes and shapes.[5] They appear at the end of the second embryonic month and reach their mature sizes at the age of about 20 years, when the permanent teeth fully develop.[4] They tend to stabilize after the second decade of life and the radiographic images could provide adequate measurements of maxillary sinuses for use in morphometric forensic analysis that cannot be approached by other means.[5]

In present times, the latest imaging modality of cone beam computed tomography (CBCT) provides images that represent a series of contiguous cross-sections like conventional CT (computerized tomography), thus providing three-dimensional information of an entity within an object that can be studied in an integrated interactive manner. The multiplanar sectioning of the reconstructed data set permits unlimited virtual dissections of the specimen without further physical damage. Also a single scan of the specimen can later be compared to any possible variety of submitted ante mortem plain film images.[6] Today there is a widespread and increasing use of CBCT for point-of-service head and neck and dentomaxillofacial imaging.[7] The applications extend from implantology, oral and maxillofacial surgeries, temporomandibular joint assessment, endodontics, orthodontics, periodontics, sinus imaging, temporal bone/lateral skull and skull base studies.[7,8] This gives the opportunity to use CBCT in forensic medicine. CBCT may be useful in some forensic contexts, offering several advantages for post-mortem forensic imaging including good resolution for skeletal imaging, relatively low cost, portability, and simplicity.[9] Certain studies on 3D reconstruction,[10] bite-mark analysis,[11] age estimation,[12] person identification[13] and anthropological assessment[14] have been done using CBCT with promising results. However their number is still limited to validate its full potential in the field of forensic science.

In a study by Amin and Hassan on maxillary sinus using multi detector CT (MDCT) scan, it was concluded that the cephalo caudal and size of the left maxillary sinuses are useful features in sex determination in Egyptians.[15] Another study by Teke et al. showed that the computerized tomography measurements of maxillary sinuses may be useful to support sex determination in forensic medicine; however, with a relatively low-accuracy rate (less than 70%).[4]

The CBCT imaging technology could broaden and facilitate many of the forensic science applications and serve as an alternative to CT. The aim of this study was therefore to evaluate whether sexual dimorphism from the height, width and length measurements of the maxillary sinus could be determined using the CBCT imaging modality.

2. Materials and methods

2.1. Collection of samples

One hundred and thirty-two CBCT scans of bilateral maxillary sinuses were retrospectively retrieved from the database of the Oral Radiology unit for a period of June 2013 to May 2014. After initial screening for adaptability to the inclusion and exclusion criteria's finally 30 CBCT scans of bilateral maxillary sinuses (60 maxillary sinuses) with 15 male and 15 female subjects and age ranging from 20 to 70 years were selected. Only high quality reconstructed images of bilateral maxillary sinuses were selected and all low quality images with blurring or artifacts caused by metallic objects were excluded. Scans that were not covering the entire extent of the sinus were excluded. Also, scans with pathologically destructive maxillary sinus from tumor, trauma, cleft or any other disease within or in the vicinity of the sinus or previous surgery were excluded. Scans with inflamed lining of the sinus were included in the study. All the scans were made using a Kodak 9000 C 3D unit (Carestream Health Inc., 150 Veronal Street, Rochester, NY 14608, USA), with variable field of view, voxel size – 76.5 × 76.5 × 76.5 μm, X-ray pulse time of 30 ms, kVp – 60 to 90 kV (max), mA – 2 to 15 Ma, exposure time of 10.8 s. Images were reconstructed using a high spatial frequency reconstruction algorithm.

2.2. Measurements

Two independent observers (both experienced radiologists) blind to the details of age and sex of the subjects, used the Digital Image Communication in Medicine (DICOM) compatible CS 3D Imaging software (version 3.2.9, copyright Carestream Health Inc.) to analyze the reconstructed image sections. All the CBCT images obtained in the DICOM format were transferred to a separate workstation and the measurements done in a quiet windowless room with dimmed lighting. The images were viewed on HP Envy Spectre XT Ultrabook 13 – 2015tu, 13.3″ diagonal HD Bright View LED-backlit Display (Hewlett Packard Company, 71004 Boeblingen, Germany) at a 1,366 × 768 resolution and measurements were done in axial and coronal cross section views. Observers were allowed to use two – fold magnification and modify screen brightness as well as scroll through the axial, sagittal and coronal sections with slice thickness standardized at 300 μm. The three straight distances (height, width, and depth), were taken on the axial and coronal cross sections, where the longest distances could be measured. The width and depth distances measured on axial section while the height distances measured on coronal cross section.

- The width was defined as the longest distance perpendicular from the medial wall of the sinus to the most lateral wall of the lateral process of the maxillary sinus in the axial view (Fig. 1).