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Case Report

Frontal Sinus as Tool in Identification

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Abstract

Identification of the dead is important in mass disasters, road traffic accidents, criminal investigations as well as accidents involving fire. The most common identification techniques are: fingerprinting, dental comparison, and DNA profiling. This review aims at delving into the use of frontal sinus as an aid in the identification process.

Keywords: Frontal Sinus; Personal Identification; Sex Determination

Introduction

When human soft tissue becomes putrid or burnt and DNA is severely damaged then fingerprints or DNA analysis cannot be performed. It is in these circumstances that anthropological methods are brought to the foray, of which comparative radiography is an important tool. Identification of remains by comparison of ante and post mortem (AM, PM) radiographs both anatomically and radiologically, is one of the most commonly employed methods. Dentomaxillofacial radiography has become a common practice in dental clinics and hospitals and hence can be utilized in identification.

The skeleton survives both natural and unnatural abuse or violence and is almost always available for identification which is plausible due to the dimorphic characteristics of the human skeleton. The skull is the second best region for identification after the pelvis. It is sexually dimorphic and aids in identification with an accuracy of up to 92%. It has various structures that aid in identification such as the dentition, cranial suture patterns, vascular groove patterns, sella turcica area of sphenoid, frontal sinuses, mastoid pneumatic air cells, and sinuses. It is said that the frontal sinus is unique to every individual, even between monozygotic twins. Hence, it comes as a natural choice for identification where the skull is concerned.

History

The application of radiology in forensic science was first introduced in 1896. Schuller in 1921 first studied frontal sinus and revealed information about its uniqueness in shape, complexity and individuality, which also included human. In 1925, Culbert and Law performed the first case of identification using the frontal sinus. It was published in 1927.

Frontal sinus - Anatomy and development

Frontal sinus is an air filled cavity located within the frontal bone that consists of paired, irregularly shaped, loculated cavities, which communicate with the nasal cavity through the infundibulum. The frontal sinus is triangular, pyramidal air cavity in between the tables of frontal bone. The thick bone of anterior wall of the frontal sinus and its curved convexity forms a barrier to resist fracture thereby providing great resiliency.

Anatomically, it can be defined as pneumatic cavities covered by the mucosa, located between the internal and external cortical bones of the frontal bone. It consists of two chambers that are asymmetrical due to independent development of each sinus. It is separated by a bony septum.

It forms embryonically from an ethmoidal cell and is not visible at birth. It begins to develop during the 4th or 5th week of intrauterine life and continues to grow after birth slowly until puberty, then rapidly until completing their growth, by anterosuperior pneumatization of the frontal recesses into the bone. It reaches maximum size at 20 years of age.

Figure 1

The thick bone of the anterior wall of the frontal sinus and its curved convexity forms a barrier to resist fracture thereby providing great resiliency.

It has been found that a force of 800-1600-foot pounds (high-impact accidents, GSW (gunshot wounds) is required to fracture the anterior wall. That is twice as much required to fracture the parasymphyseal area of the mandible and 50% more than that required to fracture the malar eminence of zygoma.

Identification using frontal sinus

Several studies in the literature have mentioned the uniqueness of frontal sinus and has been successfully used in person's identification.

Chaudhary and Singh in their study obtained Water's radiograph of fifty healthy individuals aged 20 - 40 years and used Ribeiro Fde's measurement criteria to study the variations in frontal sinus:

- The frontal sinuses, right and left were measured with the help of: Reference baseline - 10 cm line standardized at superior border of the orbit
- Greatest height on each side - maximum distance between base and upper lines of the frontal sinus
- Greatest width on each side - maximum distance between medial and lateral lines of right and left sides of the frontal sinus.

Mean and standard deviation was calculated and it was concluded that the frontal sinus was bigger and wider in males than females and was unique to every individual, thus proving that the frontal sinus can be used as an aide in personal identification. Keeping in mind that bone resorption could occur with advancing age, the sample was restricted to 40 years of age. The advantage of this technique is that it is simple and does not require expertise.

Various scholars have proposed classification of frontal sinus to help form a standardized format that can be followed when required. Schuller proposed a classification from radiographs taken in the forehead-nose position. It includes seven characteristics - septum and its deviation, upper border (scallop, arcades), partial septum, ethmoidal and supraorbital extensions, height from planum, and total breadth and position of sinus midline. Schuller, however, did not evaluate the accuracy of the method.

Frontal sinus sex determination

FSI is the parameter that is most commonly used for sex determination. Measurements of frontal sinus in lateral cephalometry are incorrect due to magnification and hence ratios were considered more reliable than single measurements. Thus, FSI, that is, the ratio of maximum height to maximum width of frontal sinus came into existence. Mid-sagittal CBCT scans of the frontal sinus have also been used for sex determination. This study, however, states that FSI is not a reliable tool for sex determination as 92% females were correctly identified but only half of males were correctly identified. Furthermore, the addition of variables such as age, height, and width did not increase the ability to predict the gender. To overcome variations in radiographic techniques such as angle, distance, and orientation of skull, lateral cephalograms have been used. In developing countries like India, CT is expensive and is

not available to the common man and hence is not used extensively in forensic radiology. A study with sinus index had shown have a significantly higher ratio in females than males and correct sex was identified.

Figure 2

The greatest height of each side (B and C) was determined from the maximum distance between the base and upper lines of the frontal sinus, and the largest width (F and G) of the frontal sinus was determined from the maximum distance between the medial and lateral lines of the right and left side of the frontal sinus.

The linear measurements obtained from each radiograph were expressed in centimeters (cm) and areas in square centimeters (cm^2).

In the radiographs, The lines that bordered the area of the frontal sinus were determined and lower border (superior border of the orbit) of the frontal sinus was standardized then measurement were done for right height (RT HT), left height (LT HT), right width (RT WD), left width (LT WD), left area (LT AR) and right area (RT AR), obtained only from the portion of frontal sinus projected above the baseline (A).

The separation between the left and the right side of the sinus was based on the frontal sinus septum in order to permit quantifying one width only on each side.

Mean and standard deviation was calculated by student's t-test and it was concluded that the frontal sinus was bigger and wider in males than females and was unique to every individual, thus proving that the frontal sinus can be used as an aide in personal identification.

Keeping in mind that bone resorption could occur with advancing age.

Discussion

Despite a strong evidence in literature stating that the variations in frontal sinus are as unique as fingerprints, its role in identification is not practically popular. The reason being several contradicting statements in various studies.

While Chaudhary and singh state that the development of the frontal sinus is completed by 18-20 years of age Most studies claim that after reaching a maximum size by 20 years of age, the frontal sinus remains stable throughout life. Several others state that with advancing age frontal sinus shows changes such as bone resorption along the walls thus making them appear larger and gradual pneumatization from atrophic changes. It is also subject to structural and developmental changes like hyperpneumatization in athletes. Pathological changes may also be visible as seen in cases of acromegaly, sinusitis, or sclerosed mastoid where bony tissue may be formed [4]. Trauma and surgery can also modify frontal sinus.

Thus, frontal sinus as a means of identification should be used with caution. Presence of unilateral or bilateral aplasia, history of orthodontic treatment, trauma, endocrine disturbances, facial asymmetries, and developmental anomalies are commonly excluded from most studies. However, these abnormalities become documented deviations from normal anatomy and may help in individualization. Although frontal sinus is radiographically visible by 5 - 6 years of age, its use in developing skulls in limited since the dimensions of frontal sinus tend to stabilize after maturity and continues to develop until it reaches a maximum size by 20 years of age.

Frontal sinus pattern matching by comparison of AM and PM radiographs is one of the most common techniques for frontal sinus identification. However, AM radiographs may not be available in all cases. In a developing nation like India where dental hygiene has not yet reached every household and ignorance is still at large,

it is highly unlikely that health records will be available for every individual. Furthermore, several parameters are used to analyze frontal sinus with no set standard and no error rates [1,2].

Conclusion

Frontal sinus is a useful aid in identification when AM dental records are absent, mandible is missing postmortem, in cases of mass disasters or when skull is available and other means of identification are bleak.

In spite of several studies propagating the use of frontal sinus for identification, it is still not a popular choice due to the lack of a standardized technique.

Conflicts of Interest

There are no conflicts of interest.

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