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Identification by Frontal Sinus

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Abstract: Verification of the identity of an unknown person is one of the most essential aspects of forensic practice. The reliability of identification of human remains by comparison of antemortem and postmortem radiographs of frontal sinus is well established as appear to be unique in each individual. A frontal sinus comparison can be particularly useful when an individual is edentulous. However, the use in practice of frontal sinus remains limited. The aim of this study is to present the method of identification through comparison of frontal sinus outlines radiographs.

Key words: Unknown person identification, frontal sinus, antemortem and postmortem radiographs, comparison methods, limited

INTRODUCTION

Verification of the identity of an unknown person is one of the most essential aspects of forensic practice. The personal identification of human remains could be performed by fingerprint, dental, anthropological, genetic or radiological examinations. DNA analysis is considered to be the best method of identification but it is expensive and not suitable for mass disasters. Study of fingerprints is a widely used and accepted procedure for this purpose, offering the advantages of storing and using the data in a precise and cost effective manner. However, when soft tissues of human remains are burnt, the fingerprint analysis cannot be carried out and the identity of the remains could be determined by other methods (Quatrehomme *et al*., 1996; Tatlisumak *et al*., 2007; Tang *et al*., 2009; Stavrianos, 2009; Uthman *et al*., 2010).

The personal identification through the comparison of antemortem and postmortem radiograph is an established procedure and many parts of the skeleton have been examined to assist in this process and has gradually gained popularity among forensic scientists. It involves the comparison of antemortem radiographs usually performed for clinical reasons with post-mortem radiograph of specific, individualizing structures. Morphological features depicted on radiographs should serve two requirements in order to be of forensic identification value: first the feature has to be unique to the individual and second it has to remain stable over time despite on-going life processes. The most reliable parts of the skeleton for identification are those which are anatomically variable or which do not exhibit change due to trauma, illness or surgical intervention (Quatrehomme *et al*., 1996; Tatlisumak *et al*., 2007; Besana and Rogers, 2010).

Frontal sinus has great variability and its structure does not change after the age of 20 years except very rare occurrences as fractures, tumours, severe infections or surgery. The anatomy of the frontal sinus remains stable throughout the course of life until old ages when gradual pneumatisation can occur from atrophic changes. Additionally, appear to be as unique to each individual as a fingerprint, even to monozygotic twins. Frontal sinuses are the most changeable part of the pneumatic paranasal system and show great differences in shape, symmetry and degree of development. The frontal sinus is increasingly applied to personal identification and is considered an ideal structure for individualization due to its inherently variable morphology, permanency throughout adulthood, resiliency to damage and the moderate availability of adequate antemortem radiographs (Quatrehomme *et al*., 1996; Tatlisumak *et al*., 2007; Tang *et al*., 2009; Uthman *et al*., 2010; Cox *et al*., 2009).

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The aim of this study is to present the method of identification through comparison of frontal sinus outlines radiographs. The performance and difficulties of this technique will also given in this study.

FRONTAL SINUS COMPARISON METHODS

Despite the method being known since 1920s, there have been few case reports on the use of comparative radiology, especially of the frontal sinuses for making positive identifications from skeletonized human remains (Cox *et al*., 2009).

Frontal sinuses are paired lobulated cavities located in the frontal bone (Fig. 1) deep to the superciliary arch and each frontal sinus opens into the corresponding middle meatus via the infundibulum and developembryonically from an ethmoidal cell. There are numerous anatomical variations in size and shape. It is possible to observe symmetry or asymmetry. Unusual conditions include an unpartitioned central sinus, unilateral absence of a sinus and agenesis. The frontal sinus has not yet formed at birth and they begin to develop during the second year of life and are not detectable in radiographs until the age of 4-6 years. It then increases in size and complexity. Development is faster after puberty and is usually complete by about 20 years of age when they reach their maximum size. The anatomy of the frontal sinus remains stable throughout the course of life as changes are rare except in elderly people when gradual pneumatisation can occur from atrophic changes. The only other factors that can modify the normal sinus are trauma, surgery and pathology. The frontal sinus is generally larger in males than females. Yet individual variation is too great to attempt sex determination from this structure. Genetic and environmental factors control the configuration of the frontal sinus within each population. The configuration of the frontal sinus is unique for each individual (Quatrehomme *et al*., 1996; Tatlisumak *et al*., 2007; Besana and Rogers, 2010).

While the skull has numerous individualizing traits that are visible on radiographs (Fig. 2), only a small proportion are of the head area. Despite this limitation the frontal sinuses have proven useful in forensic identification, particularly when antemortem dental records are not available or in cases where the teeth and or mandible are missing postmortem. The significance of the frontal sinuses in forensic individual identification lies in their unique pattern. The acceptance within the literature that no two individuals have the same sinus pattern is so strong that most of the forensic scientists no longer cite such statements. Published case studies using frontal sinuses to establish positive identification almost always involve superimposition pattern matching of ante and postmortem radiographs (Besana and Rogers, 2010). The frontal sinus comparison methods can be categorized as follows:

Subjective comparisons: There are several documented cases in which visual comparison of frontal sinus morphology has been used to identify remains. In these cases, conclusions were based solely on visual comparison of the radiographs. Sinus patterns are compared for similarity in shape via side by side comparison or superimposition. Reports of this technique show high success rates, provided the quality of the antemortem record is adequate. It has been reported that superimposition has been successful in identification cases, regardless of sex, age, cause of death and the time elapsed between the radiographs. Although, these methods show low error rates, they are criticized for being highly subjective and lacking statistical support for their reliability (Cox *et al*., 2009).

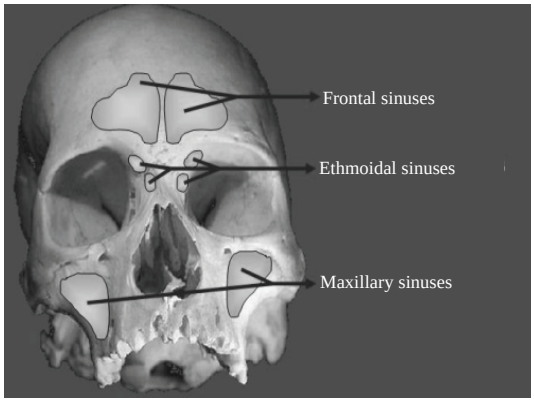

Fig. 1: Anatomical location of all paranasal sinuses including the frontal sinuses (Tatlisumak *et al*., 2011)

Fig. 2: Radiograph showing the frontal sinus region (Kirk *et al*., 2002)

Objective methods: There have been several attempts to develop objective methods of comparison designed to provide statistical parameters to conclusions of identification. These include coding systems based on morphological and metric traits as well as purely metric systems. Techniques using classification systems have shown varying degrees of success and often require visual comparison as a final confirmatory step. Codification and measurement systems provide, at best, a way to perform quick searches to narrow down suspect remains and eliminate no matches. The majority of research on the frontal sinuses has focused upon metric analysis (Besana and Rogers, 2010; Cox *et al*., 2009).

DISCUSSION

At present there are no standard techniques of comparison despite the frontal sinuses unique nature and their use in identification since the beginning of the 20th century. Different methods have been proposed for assessing the standard radiograph of the frontal sinus based on size, shape and symmetry. Numerical classifications such as those used for fingerprint analysis may be used for standardization. If parameters of the frontal sinus and their classification were standardized, data of the frontal sinus could be stored as a database and could be exchanged between different laboratories and the frontal sinus patterns could be compared. The outline of the frontal sinus is irregular and the dimensions of the frontal sinus are more convenient for being exactly measured. One of the common guidelines in the literature regarding the matching of antemortem radiographs to postmortem radiographs involves the distance and angle at which each radiograph is taken (Quatrehomme *et al*., 1996; Tang *et al*., 2009; Besana and Rogers, 2010).

Although, probability analysis supports the strength of metric differentiation of the frontal sinuses, testing of this method shows that it has inherently high error rates that render it unsuitable for use in an individualizing setting. Discrete traits are also useless for individualization with the frontal sinuses because of the low levels of discriminating power provided by the probability analysis. Superimposition pattern matching provides the simplest method of obtaining an individual match from the frontal sinuses with the highest levels of accuracy and precision and the lowest level of error. This method should be utilized as the standard methodology when trying to obtain an individual identification using the frontal sinuses. Only by meeting these stringent requirements can the frontal sinuses be utilized as individual identifiers in a court of law (Besana and Rogers, 2010).

Table 1: The absence of frontal sinus in the research conducted by Cameriere *et al*. (2005)

		Absence of frontal sinus (%)			
			Unilateral		
Sex	n	Bilateral	Left	Right	Total
Male	41	6 (14.6)	0 (0.0)	3 (7.3)	3 (7.3)
Female	57	4 (7.0)	5 (8.8)	0 (0.0)	5 (8.8)

In their study, Smith *et al*. (2010) investigated the hypothesis that human examiners are able to identify correct matches more accurately than digital methods even when the frontal sinuses being compared are small or less featured. According to the researchers this was because of the fact that human examiners are more discriminating than digital methods and because humans are able to take into consideration other features present on the radiograph images. Also, of interest is the effect, if any of examiners' experience level on the ability to identify matches (Smith *et al*., 2010).

Cameriere *et al*. (2005) reported that superiority of the side, outline of the upper border (left), outline of the upper border (right), partial septa and supra-orbital cells were discrete variables. They thought that the abovementioned parameters were independent in individuals with bilateral frontal sinuses. In their research they calculated the absence of frontal sinus (Table 1) from the sample used.

Ubelaker (1984) used superimposition to determine that any two individuals have at least three points of difference in their frontal sinuses. Uthman *et al*. (2010) showed in their study that no two images appeared the same. Even identical twins have differently formed sinuses.

In the research of Besana and Rogers (2010), it was determined that positive identification by metric measurements was unsuitable, a discrete approach was attempted. The final method of personal identification using the frontal sinuses examined in this research was superimposition.

CONCLUSION

The reliability of identification of human remains by comparison of antemortem and postmortem radiographs of frontal sinus is well established as appear to be unique in each individual. A frontal sinus comparison can be particularly useful when an individual is edentulous. However, the use in practice of frontal sinus remains limited. New approaches and concepts should be developed for the advanced use of the frontal sinus like fingerprints.

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