Lateral angle of the petrous bone as a sex predictor of cremated human remains

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1. Introduction

Sex determination of human cremated remains is difficult to achieve because of severe destruction, shrinkage and warping caused by fire exposure. The lateral angle of the internal acoustic meatus provided promising results for sex determination of adult remains (Norén et al. 2005). This anatomical feature is located on the *pars petrosa* of the temporal bone **(Figure 1)**. Although cremated temporal bones are usually found in a very fragmentary state, the petrous portion often survives cremation. An assessment of this methodology reliability was carried out over a sample of Portuguese modern known-sex cremated skeletons. Some preliminary results of a PhD research currently in progress are presented.

2. The sample

Sample: 67 adult individuals (28 females/39 males) aged from 35 to 97 years-old. It includes 46 bones from the left side and 52 from the right side.

Sub-sample 1: 40 individuals (17 females/23 males) cremated immediately after death. It includes 29 left temporal bones and 29 from the right side.

Sub-sample 2: 27 individuals (11 females/16 males) previously inhumated for 5-7 years before being exhumed and finally cremated. It includes 17 left temporal bones and 23 from the right side.

3. The Lateral Angle method

The lateral angle is composed by the posterior outer surface of the petrous bones and the edge of the internal meatus accusticus **(Figure 2)**. A 45º sectioning point is used to discriminate between females and males. This method attained 83% of correct adult sex classification on a previous research (Norén et al. 2005).

A silicone-based cast of the internal meatus accusticus was taken from each bone. Subsequently, the cast was bisected following the longitudinal axis of the auditory canal. The profile of the cast was then photographed and the angle was measured on-screen using the *Adobe Photoshop CS2*® software. Some casts were considered unmeasurable and not included in the analysis.

4. Results

4.1. Intra-observer error

The casts were measured in two distinct moments. The *Cohen's Kappa-statistic* concerning the sex allocation of each cast for both observations is 0,78 indicating substantial agreement.

4.2. Lateral asymmetry

The agreement for sex determination using the two temporal bones from each individual was calculated with the *Cohen's Kappa-statistic*. The result of 0,16 indicates slight agreement.

4.3. Sex determination

The lateral angle method obtained 66,1% of temporal bones correctly classified according to sex on the overall sample. This procedure attained only 57,9% of successful sex allocation on the sub-sample 1. The individuals from the sub-sample 2 were accurately sex determined on 79,2% of the cases **(Table 1)**.

	Females			Males			Total		
	Left	Right	Both sides	Left	Right	Both sides	Left	Right	Both sides
Overall sample	22,5% (n=9)	50,0% (n=14)	39,1% (n=23)	85,0% (n=20)	78,9% (n=19)	82,1% (n=39)	66,6% (n=29)	66,7% (n=43)	66,1% (n=62)
Sub-sample 1	14,3% (n=7)	28,6% (n=7)	21,4% (n=14)	91,7% (n=12)	66,7% (n=12)	79,2% (n=24)	63,2% (n=19)	52,6% (n=19)	57,9% (n=38)
Sub-sample 2	50,0% (n=2)	71,4% (n=7)	66,7% (n=9)	75,0% (n=8)	100,0% (n=7)	86,7% (n=15)	70,0% (n=10)	85,7% (n=14)	79,2% (n=24)

Table 1: Sex determination accuracy for all samples.

4.4. Sample-specific sectioning point

The measurements taken on our observations were used to calculate a sample-specific sectioning point to discriminate between females and males. This was done for the overall sample and the two sub-samples by estimating the weighted arithmetic mean of all lateral angle measurements according to amount of individuals of each sex. This procedure did not improve sex allocation in any of the samples **(Table 2)**.

	Calculated sectioning point	Females			Males			Total		
		Left	Right	Both sides	Left	Right	Both sides	Left	Right	Both sides
Overall sample	39,98º	55,6%	35,7%	43,5%	65,0%	47,4%	56,4%	62,1%	54,6%	58,1%
Sub-sample 1	39,75º	42,9%	37,5%	40,0%	54,5%	38,5%	45,8%	50,0%	38,1%	43,6%
Sub-sample 2	41,80º	50,0%	71,4%	66,6%	75,0%	85,7%	80,0%	70,0%	78,6%	75,0%

Table 2: Sample-specific sectioning points and respective sex determination accuracy.

References

Norén, A., N. Lynnerup, et al. (2005). "Lateral angle: a method for sexing using the petrous bone." American Journal of Physical Anthropology **128**: 318-323.

Whyte, T. (2001). "Distinguishing remains of human cremations from burned animal bones." Journal of Field Archaeology **28**(3/4): 437-448.

Figure 1: Two cremated *pars petrosae* from the left and right temporal bones

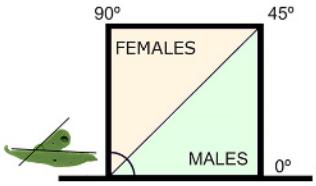

Figure 2: Cast of the auditory canal exemplifying the lateral angle measurement. Angles lower than 45º are attributed to males and angles above 45º are attributed to females.

5. Discussion

The lateral angle method has a less than perfect repeatability score indicating that two observations over one same sample will present small differences concerning sex determination. In addition, lateral asymmetry concerning petrous bones from both sides is very significant.

The overall sample and the sub-sample composed by primarily cremated individuals were poorly classified according to sex but we obtained reasonable results for the sub-sample composed by secondarily cremated individuals. The explanation for these results may be related to heat-induced bone changes. Bone warping is commonly found on primarily cremated bones and usually absent from dry bones (Whyte, 2001). This occurrence may prevent the use of the lateral angle method on the first case and may also be responsible for the significant lateral asymmetry we have recorded.

The accuracy of the lateral angle was significantly higher for males than for females. The sample-specific sectioning points did not improve sex determination. There is considerable overlapping of lateral angle measurements according to sex for the overall sample **(Fig. 3)** and for sub-sample 1 **(Fig. 4)**. We obtained better results for the sub-sample 2 where overlapping is not as significant **(Fig. 5)**. The overlapping combined with the small sample analysed may help explain the low accuracy obtained by using sample-specific sectioning points.

Figures 3-4-5: Distribution of each sex lateral angle measurements obtained on the:

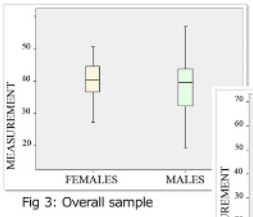

Fig 3: Overall sample

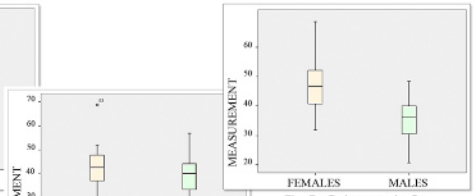

Fig 5: Sub-sample 2

Fig 4: Sub-sample 1

6. Final Comments

The results here provided were obtained on a relatively small sample. Only further research on a larger number of individuals will be able to confirm or nullify our preliminary conclusions. Also, the estimation of the inter-observer error may elucidate about the replicability of the lateral angle method using the *Adobe Photoshop CS2*® software. This is an issue to be addressed in the future.

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