Morphometric Study Of Mastoid Canal And Suprameatal Triangle Of Human Egyptian Skull,With Gender Determination

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Abstract: Purpose: This study aimed to evaluate the anatomical variations of mastoid canal, mastoid groove and suprameatal triangle and to evaluate the use of mastoid process as atool for sex determination in unidentified skeleton. **Material and methods**: The mastoid region of 100 dry human skulls were observed for prescence of mastoid canal and groove.If any, ametallic wire was passed through the canal for its confirmation and then the length was measured. Inspection of suprameatal spine for its shape and size and determine the depth of suprameatal triangle or depression (deep or shallow).The following measurements were taken using vernier caliper:mastoid triangle measurements,mastoid length and mastoid breadth. **Results: M**astoid canal was present in 28% of total 100 skull either unilaterally or bilaterally.mastoid groove was present in 24% of total 100 skull.both mastoid canal &groove were present in 8% of total 100 skull.suprameatal triangle was deep in 46% of total skulls and it was shallow in 30% of total skulls.The most prevalent type of supameatal spine was crest type (46%) while triangular type was present in 26% of total skulls.There were a highly significant difference between both sex ($p< 0.01$) as regard mastoid triangle measurements,mastoid length and mastoid breadth. **Conclusion:** It was possible to conclude that mastoid canal,mastoid groove and the suprameatal triangle presents anatomical variations that may help neurosurgeons and otologic surgeones during surgical procedures which involve access to structure in posterior cranial fossa and mastoid air system.

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Key words: mastoid canal, suprameatal triangle, mastoid process, mastoidectomy.

1. Introduction

Mastoid canal is the canal formed in the mastoid region of the temporal bone of the skull and perforated lateral wall of this canal is called as mastoid groove.This vascular canal and groove are of variable caliber and length and the knowledge of them is very important for neurosurgeons and otolaryngologists [(7)].

Since the suprameatal triangle cover the lateral wall of the mastoid antrum, it is generally accepted as useful anatomical landmark for otologic surgeons during mastoidectomy [(14)].The suprameatal depression may show a bony specule or crest in its anterior margin,the suprameatal spine which varies in shape,size and position [(19)].Because of their anatomical positions,both the suprameatal triangle and spine are of clinical importance to otologic surgeons [(4)].

Identification of human skeletal remains is of major importance in medicolegal situations such as criminal cases and mass disasters [(16,6)]. The sex determination is best assessed from the pelvis,while the skull is considered as second area for sex determination [(11,24)]. followed by other bones such as femure and humerus [(20)].Male and female crania can be discriminated with 95% confidence by using the mastoid process [(5)].

Mastoid process is abone less prone to damage due to its anatomical position and it is one of the slowest,late growing region of the cranium, so it show higher degree of sexual dimorphism [(9,21)]

2. Material and Methods

This study was conducted on 100 adult Egyptian human dry skulls of known sex. The studied skulls were 44 male skulls and 56 female skulls. The selected skulls were without any anomalies, fractures or pathology that might affect the normal measurements.The gender of the chosen cranium was determined according to standard criteria used in forensic medicine.

All skulls were subjected to certain procedures which were done bilaterally and directly on the dry skull by using the following tools: A caliper with 0.01 mm precision**,**metalic wire, ruler, needle with a rubber stop.

Three craniometric points were studieded on each skull:

- Porion (po):superior point of external auditory meatus.
- Mastoidale (MS):most inferior point of the mastoid process.

• Asterion (AST):the meeting point of lambdoid,occipitomastoid and partietomastoid sutures.

The following measurements were taken using the caliper:

1-Mastoid length: the straight distance from mastoidale to the upper rim of root of zygomatic process of temporal bone.

2-Mastoid breadth:the straight distance from postrior end of incisura mastoidea(digastric notch)to the nearest point of posterior border of external auditory meatus.

3-Mastoid triangle measurements which include:

a-Asterion –Mastoidale length(AST-MS):it is the straight distance between asterion and mastoidale. (both right and left sides).

b-Asterion –Porion length (AST-PO):it is the straight distance between Asterion and Porion.(both right and left sides).

c-Porion –Mastoidale length(PO-MS):it is the straight distance between porion and mastoidale.(right and left side).

Observations and measurements in the Mastoid region**:**

• prescence of mastoid canal and groove and if they were unilateral or bilateral. single or double and if both mastoid canal and groove were found together on the same side.Ametalicwire was passed through the mastoid canal for its confirmation (only those skulls which had canals patent to the metalic wire was considered as possessing mastoid canal). The length of mastoid canal and groove was measured by passing the metalic wire then take its length with help of the caliper.

• Inspect the prescence or absence of Suprameatal spine.In case of prescence of suprameatalspine,its type was determined (2 types of suprameatal spine were recorded: crest type and triangular type). The size of suprameatal spine was recorded and they were classified to small,medium and large size.

• Suprameatal triangle (depression): if it was present or absent and if it was shallow or deep.the relation between SMD and SMS was recorded relative to the shape and the size.

Statistical analysis:

All the distances were measured with vernier caliper to the nearest millimeter. All measurements and frequencies of the data were tabulated and separated according to the sides and genders. Basic descriptive statistics were employed to analyze the datawere done by the computer software SPSS. The mean, standard deviation and range for each of the measurements were assessed. Comparison of the values of all measurements was made between sides of each subject and also comparisons between genders were made.

In the statistical comparison between the different groups, the significance of difference was tested using one of the following tests:-

• Student's *t*-test:- Used to compare mean of two groups of quantitative data.

• Paired t test:- Used to compare mean of two variables of quantitative data in the same group.

• Inter-group comparison of categorical data was performed by using chi square test (X^2-value), Mcnemar and fisher exact test (FET).

A P value <0.05 was considered statistically significant (S) while >0.05 statistically insignificant P value <0.01 was considered highly significant (HS) in all analyses.

3. Results

The mastoid canals were present in 28% of total skulls.Among these 28 mastoid canals,4(4%) were bilateral,12(12%) were unilateral on the left side,12(12%) were unilateral on the right side. Both mastoid canals and grooves were found together on the same side in 8 % of total skulls (Table 1) (Figs.1 and 2). The mean length of mastoid canal on the right side was 7.5±3.69 mm in male and 6.75±3.33mm in female. the mean length on the left side was 6.08±3.64 mm in male and 5.63±3.15 mm in female with no significant difference between male and female skulls.

Mastoid grooves were present in 24% of total skulls. 4% were bilateral,12% were unilateral on the left side, 8% were unilateral on the right side (Table 1). The mean length of mastoid groove was 9.33± 4.79 mm in male and 10.8 ± 4.31 mm in female on the right side with no significant difference between both sexes (Fig. 3). it was 5.0 ± 0.0 mm in male and 10.53±3.86 mm in female on the left side with highly significant difference between both sexes.

As regard the types of suprameatal spine (SMS), crest type was present in 20 male skulls (45.5%) and 20 female skulls (35.75%) on the right side,while it was present in 28 male skulls (63.6%) and 24 female skulls (42.9%) on the left side (fig.1).Triangular type was present in 12 male skulls (27.3%) and in 16 female skulls (28.6%) on the right side. while it was present in 8 male skulls (18.2%) and 16 female skulls (28.6%) on the left side (table 2)**.**There were insignificant difference between both sex and both sidesas regard the types of SMS.

As regard the size of suprameatal spine (SMS),it was small in 16 skull(16%) on the right side and in 32 skull (32%) on the left side. The mean size of small SMS was 1.43+_0.11mm in male and 1.17+_0.13mm in female.SMS was medium size in 28 skull (28%) of total number on the right side and in 24 skull (24%) on the left side (fig. 1). The mean size of medium SMS was 2.23 ± 0.18 mm in male and 2.22 ± 0.1 mm in female.SMS was large in size in 24 skull (24%) of

total number on the right side and in 20 skull (20%) of total number on the left side (fig. 2). The mean size of large SMS was in 3.56 ± 0.41 mm male and 2.94 ± 0.11 mm in female (table 3). The statistical analysis of these data indicated that there was significant difference between both sexes on the right side while there was highly significant difference between both sexes on the left side.

Suprameatal depression (SMD) was absent in 8 male skulls(18.2%) and 20 female skulls (35.7%) on the right side, while it was absent in 4 male skulls (9.1%) and in 16 female skulls (28.6%) on the left side.It was deep in 24 male skulls (54.5%) and in 16 female skulls (28.6%) on the right side,while it was deep in 32 male skulls (72.7%) and 20 female skulls (35.7%) on the left side (Fig.2). SMD was shallow in 12 male skulls (27.3%) and in 20 female skulls (35.7%) on the right side while it was shallow in 8 male skulls (18.2%) and in 20 female skulls (35.7%) on the left side (Table 4) (Fig.3). There was significant difference between both sexes on both sides.

Mean (AST-MS) length on the left side was 5.06± 0.28 cm in male and 4.39± 0.29 cm in female while on the Rt side it was 5.22± 0.31 cm in male and 4.44± 0.35 cm in female. Mean (AST-PO) length on the left side was 4.66 ± 0.32 cm in male and 4.26± 0.21 cm in female while on the right side it was 4.65± 0.22 cm in male and 4.23± 0.19 cm in female. Mean(PO-MS) length on the left side was 3.25± 0.12 cm in male and 2.63± 0.27 cm in female while on the right side it was 3.29± 0.14 cm in male and 2.76± 0.27 cm in female with a highly significant difference between male and female skulls (Table 5).

Mean mastoid length(ML) was 3.70±0.11 cm in male and 3.07±0.38 cm in female.Mean mastoid breadth (MB) was 2.80±0.24 cm in male and it was 2.31±0.29 cm in femalewith a highly significant difference between male and female skulls (Table 5).

Table 1: Shows the distribution of mastoid canals and grooves in the mastoid region

Side / **Parameter**	**Bilateral**	**Unilateral**		**Total**
		Left side	**Right side**	
Mastoid canal (MC)	4(4.0%)	12(12.0%)	12(12.0%)	28(28%)
Mastoid groove (MG)	4(4.0%)	12(12.0%)	8(8.0%)	24(24.0%)
Both MC&MG	-	8(8.0%)	-	8(8.0%)

Table 2: shows Sex differences in the types of suprameatal spine (SMS) on both sides

Side	**Rt side**						**Lt side**					
	Male		**Female**		**Total**		**Male**		**Female**		**Total**	
Type	No	%	No	%	No	%	No	%	No	%	No	%
Absent	12	27.3	20	35.7	32	32.0	8	18.2	16	28.6	24	24.0
Crest	20	45.5	20	35.7	40	40.0	28	63.6	24	42.9	52	52.0
Triangular	12	27.3	16	28.6	28	28.0	8	18.2	16	28.6	24	24.0
Total	44	100	56	100	100	100	44	100	56	100	100	100
x2 test	1.15						4.26					
***P* value**	0.563						0.119					

Table 3:shows Sex differences in the size ofsuprmeatal spine (SMS) on both sides

Side	**Rt side**						**Lt side**					
	Male		**Female**		**Total**		**Male**		**Female**		**Total**	
Size	No	%	No	%	No	%	No	%	No	%	No	%
Absent	12	27.3	20	35.7	32	32.0	8	18.2	16	28.6	24	24.0
Large	16	36.4	8	14.3	24	24.0	8	18.2	12	21.4	20	20.0
Medium	12	27.3	16	28.6	28	28.0	24	54.5	0	0.0	24	24.0
Small	4	9.1	12	21.4	16	16.0	4	9.1	28	50.0	32	32.0
Total	44	100	56	100	100	100	44	100	56	100	100	100
FET	7.72						51.13					
***P* value**	0.049						0.001					

Table 4: shows the Sex differences in the depth of suprameatal depression(SMD) on both sides

Side Depth of SMD	**Rt side**						**Lt side**					
	Male		**Female**		**Total**		**Male**		**Female**		**Total**	
	No	%	No	%	No	%	No	%	No	%	No	%
Absent	8	18.2	20	35.7	28	28.0	4	9.1	16	28.6	20	20.0
Deep	24	54.5	16	28.6	40	40.0	32	72.7	20	35.7	52	52.0
Shallow	12	27.3	20	35.7	32	32.0	8	18.2	20	35.7	28	28.0
Total	44	100	56	100	100	100	44	100	56	100	100	100
x2 test	7.41						13.87					
***P* value**	0.025						0.001					

Table 5: shows Sex difference in different cranial measurements.

Sex	Male group (44) Mean± SD (range) in cm	Female group (56) Mean± SD (range) in cm	St t test	*P* value
AST-MS (Lt)	5.06±0.28(4.5-5.5)	4.39±0.29(4.16-4.75)	11.57	0.001
AST-PO (Lt)	4.66±0.32(4.26-5.2)	4.26±0.21(4.0-4.6)	7.55	0.001
PO-MS (Lt)	3.25±0.12(3.05-3.5)	2.63±0.27(2.3-3.0)	13.97	0.001
AST-MS (Rt)	5.22±0.31(4.76-5.6)	4.44±0.35(3.9-4.84)	11.55	0.001
AST-PO (Rt)	4.56±0.22(4.21-4.8)	4.23±0.19(3.9-4.5)	8.04	0.001
PO-MS (Rt)	3.29±0.14(3.1-3.53)	2.76±0.27(2.3-3.12)	12.2	0.001
Mastoid length(ML)	3.70±0.11(3.5-3.9)	3.07±0.38(2.25-3.95)	10.69	0.001
Mastoid breadth(MB)	2.80±0.24(2.55-3.4)	2.31±0.29(1.95-3.1)	8.86	0.001

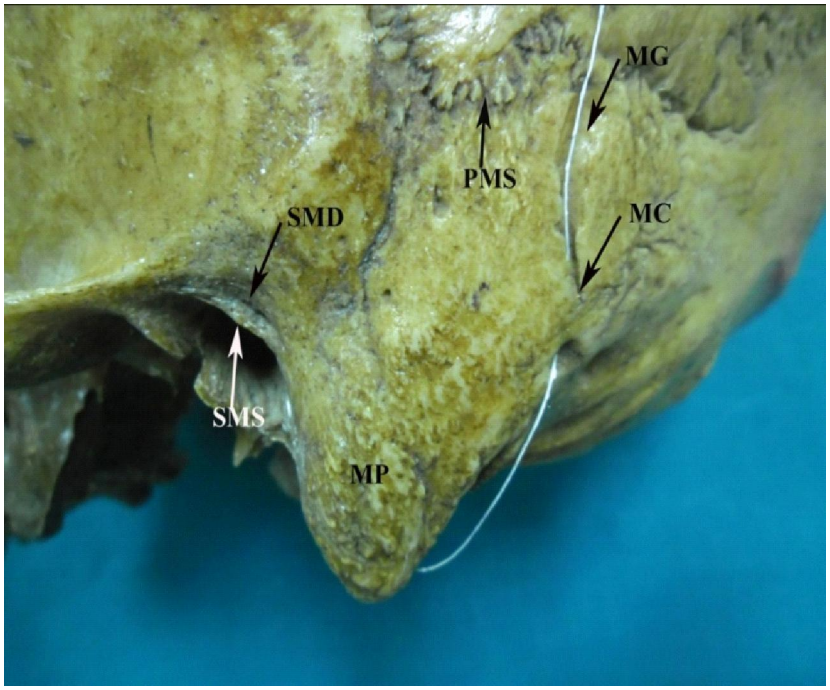

Fig (1): Aphotograph of lateral view of the mastoid region of adult male skull showing: unilateral left side mastoid canal (MC) 5 mm in length,well marked mastoid groove (MG) at the end of MC, left crest type suprameatal spine (SMS) medium in size (2mm), shallow suprameatal depression (SMD). Note:Mastoid process (MP), Parietomastoid suture (PMS).

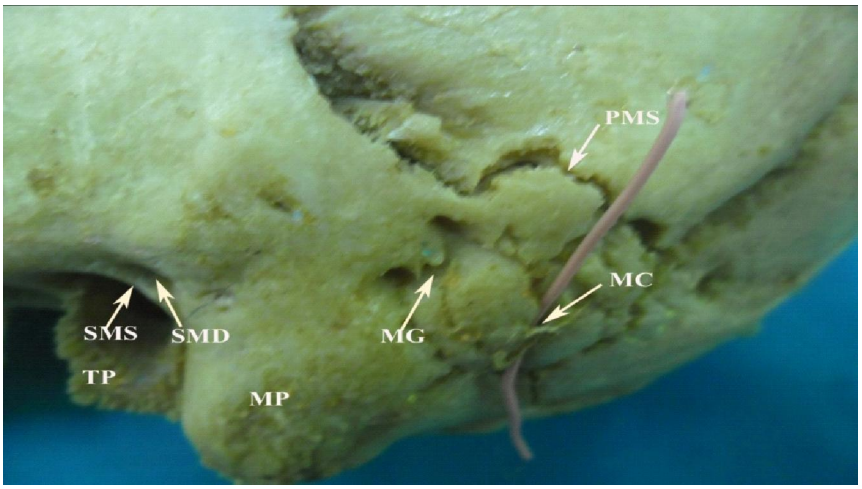

Fig (2): Aphotograph of lateral view of the mastoid region of adult female skull showing: both mastoid canal (MC) 2 mm in length and mastoid groove (MG) 7 mm in length on the left side, left crest type suprameatal spine (SMS) large in size (3mm), deep suprameatal depression (SMD). Note:Mastoid process (MP), Tympanic plate (TP), Parietomastoid suture (PMS).

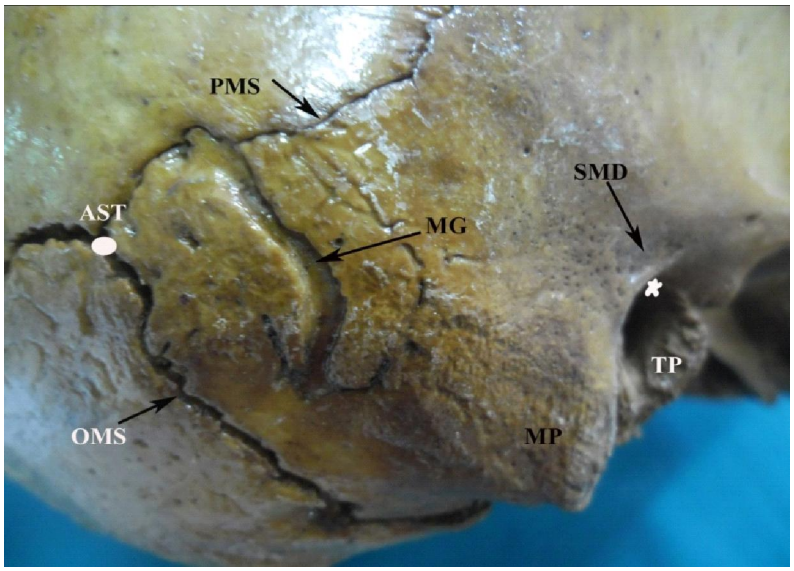

Fig (3): Aphotograph of lateral view of the mastoid region of adult female skull showing: right side mastoid groove (MG) 15 mm in length, absent suprameatal spine (SMS), shallow suprameatal depression (SMD). Note:Mastoid process (MP), Tympanic plate (TP), Parietomastoid suture (PMS), Asterion (AST), Occipitomastoid suture (OMS).

4. Discussion

In the present study,the percentage of prescence of mastoid canal was 28% of total skulls.when compared to the results of **Hussain *et al.* (2012)** [10] on south Indian skulls, the percentage of mastoid canal was 59.2%. **Singh *et al.* (2004)** [23] found that the the mastoid canal was present in 52.4% in Japanese skulls**.** While it was 41% in Indian skulls in the study done by **Choudhry *et al.* (1996)** [3].

There was no double mastoid canal on the same side in this study but there was both mastoid canal and mastoid groove on the same side in 8% of total skulls.When compared to the results by **Hadimani and Bagoji (2013)** [7] on north karnataka skulls,the percentage of double mastoid canal was 1% on left side and the percentage of both mastoid canal and mastoid groove on the same side was 2%.

The importance of the structure in the mastoid area has increased due to the increasing use of transtemporal route for surgical procedures which are performed by neurosurgeons and otolaryngologists. **Hadimani and Bagoji (2013)** [7]. The percentage of mastoid groove was higher in this study (24%) when compared to results on other races.**Singh *et al.* (2004)** [23] found that the percentage of mastoid groove was 13.56% in Japanese skulls. And this percentage was

18% in north karnataka skulls by the results of (**Hadimani and Bagoji (2013)** [7]. While it was 20% in south indian skulls by **Hussain *et al.* (2012)** [10].But the percentage of the prescence of the mastoid groove was higher in the present study (24%).

In most previous studies, the suprameatal spine (S.M.S) was mostly observed as a crest type by **Peker *et al.* (1998) and Hauser and De stefano (1989)** [19,8].Also in the present study,most of S.M.S was crest type (46%) compared to triangular type which was present in (26%) of total skulls. While **Aslan *et al.* (2004)** [1] found that the percentage of crest type(40%) was equal to the percentage of triangular type (40%) in Turkish skulls.

Clear determination of suprameatal triangle and suprameatal spine is clinically important for localization of the mastoid antrum and tegmen tympani,since it is asignificant topographic land mark separating the middle cranial fossa and the mastoid antrum.**Romanes (1992)** [22].

Peker *et al.* (1998) [19] found that the percentage of shallow SMD was higher in female (39% on right side and 39.8% on left side) than in male (28.4% on right side and 25.8% on left side) in turkish skulls. This result nearly similar to the results in the present study which reported that the incidence of absent and shallow SMD was significantly higher in femal (35.7% on right side and the same percentage on left side) than in male (27.3% on right side and 18.2% on left side) on both sides.

In contrast to the incidence of shallow SMD,the percentage of deep SMD was significantly higher in male (54.5% on right side and 72.7% on left side) than in female (28.5% on right side and 35.7% on left side). **Peker *et al.* (1998)** [19] also found that the incidence of deep SMD was higher in male (36.1%) than in female (23.8%) in turkish skulls.

The results of this study show that there was asexual dimorphism in the dimenstions of the mastoid region.all dimenstions showed ahighly significant difference between male and female which is of major importance in identification of human skeletal remains in medico-legal situations.**Vineeta *et al.* (2011)** [27] reported nearly similar results on Indian skulls.

In this study,the mean asterion-mastoidale(AST-MS) length was (5.06±0.28 cm on left side and 5.22±0.31 cm on the Right side) in male and it was (4.39±0.29 cm on left side and 4.44±0,35 cm on Right side) in female with ahighly significant difference between both sex (p=0.001) on both sides.This result is in agreement with results by **Jain *et al.* (2013)** [12] on Indian skulls who found that the mean AST-MS length was significantly higherin male (4.92±.80) than in female (4.47±0.72) on both sides.But **Suazo *et al.* (2008)** [25] found that the mean AST-MS length was nearly equal in male (5.02±.49) and female (5.01±.51) in Brazilian skulls.

The mean asterion-porion (AST-PO) length was significantly higher in male (4.66±0.32 cm on left side and 4.56±0.22 cm on right side) than in female (4.26±0.21 cm on left side and 4.23±0.19 cm on right side) on both sides.This result nearly similar to results by **Jaja *et al.* (2013)** [13] on Nigerian skulls in which there was significant difference between male (4.60±0.71 cm) and female (4.30±0.65 cm) in AST – PO length on left side.

Bhaskar *et al.* (2013) [2] found that the mean mastoid length was 3.56±0.39 cm in male and 3.05±0.40 cm in femalein south Indian skulls. In this study,the mean mastoid length was 3.70±0.11 cm in male and it was 3.07±0.38 cm in female with highly significant difference between both sex (p=0.001). While **Passey *et al.* (2015)** and **Noack (2015)** [18,17] reported lower results in Asian races (mean mastoid length was 2.97 cm in male and 2.45 cm in female) and in Norwegian population (mean mastoid length was 2.86 cm in male and 2.49 cm in female) respectivly.

In the present study, the mean mastoid breadth was significantly higher in male (2.80±0.24 cm) than in female (2.31±0.29 cm) (p=0.001), compared to results by **Nagaoka *et al.* (2008)** [15] on Japanese skulls found that the mean mastoid breadth was 20.40 ±.25 cm in male and 2.21±.26 cm in female.while **Sumati *et al.* (2010)** [26] reported lower results on north Indian skulls (mean mastoid breadth was 11.46± 2.7 mm in male and 8.68 ± 2.59 mm in female).

Conclusion

It was possible to conclude that mastoid canal,mastoid groove and the suprameatal triangle presents anatomical variations that may help neurosurgeons and otologic surgeones during surgical procedures which involve access to structure in posterior cranial fossa and mastoid air system. All measurements of the mastoid region show ahighly significant difference between both genders,so mastoid process can be used in sex determination with high degree of confidence and is of major importance in medicolegal situations.

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