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# **Morphology and variability of the facial nerve trunk dependent on branching pattern, gender, anthropometric type and side of the head in Moldovan population**

A. Babuci et al., Variability of the facial nerve trunk

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## **Abstract**

**Background:** Knowledge concerning variability of the facial nerve trunk (FNT) direction after its exit through the stylomastoid foramen is of a great clinical significance for maxillofacial surgeons, otorhinolaryngologists, oncologists, specialists in plastic and aesthetic surgery. The aim of our study was to establish the variation of the FNT direction and its peculiarities dependent on branching pattern, gender, anthropometric type and side of the head.

**Materials and methods:** The direction of the FNT and its branching pattern were studied on 75 dissected hemifaces of adult formalized cadavers (59 male/16 female), and the morphometry of the FNT length, width and bifurcation angle was carried out.

**Results:** Seven branching patterns of the facial nerve were established: Type I – 18.7%, Type II – 14.7%, Type III – 20%, Type IV – 14.6%, Type V – 5.3%, Type VI – 18.7%, and Type-NI – 8% (bizarre types). The FNT had a descending direction in 73.3% of cases; ascending FNT – 9.3% (including 5.3% of very short diffuse branching trunks and 1.3% of arch-shaped FNT); horizontal FNT – 10.7%; number variants – 6.7%. The male/female ratio of the descending FNT was 69.5%/87.4%; ascending – 10.2%/6.3%; horizontal – 11.9%/6.3%; number variants – 8.4% (only in male). The right/left ratio of the descending FNT was 62.9%/82.5%; ascending – 11.4%/7.5%; horizontal – 11.4%/10%; number variants – 14.3% (only on the right side). The ratio of the descending FNT in mesocephalic type (MCT) / brachycephalic type (BCT) / dolichocephalic type (DCT) was respectively 70.6%/100%/66.7%; ascending – 12.1%/0%/0%; horizontal – 12.1%/0%/11.1%. Numerical variants in MCT – 5.2%, in DCT – 22.2%. The mean number of FNT in MCT/BCT/DCT was respectively 1.07/1.0/1.22.

**Conclusions:** Three main directions are characteristic for FNT: the descending, ascending and horizontal ones, which vary dependent on branching pattern, gender, shape and side of the head.

**Key words:** facial nerve, branching types, variation, peculiarities, morphometry

## INTRODUCTION

The facial nerve morphology, its variability and specific features are the subject of interest of many researchers all over the world. Nevertheless, the majority of the published papers describe only the variability of the facial nerve branching types, its connections and topography of the parotid plexus towards neighboring anatomical structures [1–4, 6, 8, 10–12]. Non-articles were found on the variability of the FNT direction dependent on gender, anthropometric type and side of the head, or branching pattern.

Taking into consideration that the rate of the parotid tumors, polytrauma with involvement of the head and neck regions, as well as the demand for plastic surgery and rejuvenating procedures have increased lately, it is imperative to have a new approach towards the facial nerve morphology.

The purpose of our study was to establish the direction and morphological peculiarities of the FNT dependent on branching pattern, gender, anthropometric type and side of the head.

## MATERIALS AND METHODS

The variability and morphological peculiarities of the FNT were studied on 75 hemifaces of adult formalized cadavers (59 male/16 female) in the period 2014-2022. The direction, length, width, bifurcation angle, number variation of the FNT and branching pattern of the facial nerve were analyzed.

Each cadaver was carefully examined on presence of any deformities or damages of the soft tissues of the face and only the hemifaces with intact soft tissues were used for our study.

Ahead of dissection, the longitudinal and transverse dimensions of each head were measured. The longitudinal dimension was measured between the glabella and opisthocranion and the transverse one between the right and left euryons.

The anthropometric type of the head was established according to the formula:

$$\frac{\text{Transverse diameter} \times 100}{\text{Longitudinal diameter}}$$

The male specimens were represented by 59 hemifaces (78.7%), and the female ones by 16 hemifaces (21.3%). The right side hemifaces constituted 40 samples (53.3%) and the left ones – 35 (46.7%). The male/female ratio of the right specimens was 82.9%/17.1% and those of the left – 75%/25%. In male individuals the ratio of the right/left hemifaces was 49.2%/50.8% and in female it was 37.5%/62.5%.

The majority of the dissected samples, 58 hemifaces (77.3%), belonged to the MCT. The BCT was represented by 8 hemifaces (10.7%) and the DCT included 9 hemifaces (12%). The ratio of the male/female hemifaces dependent on the anthropometric type of the head for MCT was 81.3%/62.5%, for BCT – 6.8%/25% and for DCT – 11.9%/12.5%. The right/left ratio of samples in MCT was 77.2%/77.5%, in BCT – 11.4%/10% and in DCT – 11.4%/12.5%.

The branching patterns of the facial nerve were determined according to Davis classification [2]. In our study, each of those six classical patterns of branching had an atypical subtype, but Type III had two atypical subtypes. For a relevant statistical analysis each atypical subtype was added to the corresponding classical type of branching and all the bizarre types were included into the "Type-NI" (non-identified in the specialty literature types).

The quantitative and qualitative variables were analyzed using the Microsoft Excel 2016 processing program and methods of descriptive and inferential statistics.

The indicators of variability were calculated using the following formulas:

1. Standard deviation (s): function STDEV

$$s = \sqrt{\frac{\sum (X_i - \bar{X})^2}{n-1}}$$

(1)

Where:  $\sum$  – sum;  $X_i$  – individual value of the  $X$  variable;  $\bar{X}$  – arithmetic mean;  $n$  – number of cases.

2. Coefficient of variation (CV):

$$CV = \frac{s}{\bar{X}} \quad (2)$$

Where:  $s$  – standard deviation;  $\bar{X}$  – arithmetic mean;  $CV \leq 10$  homogenous population;  $10 < CV \leq 20$  relatively homogenous population;  $20 < CV \leq 30$  relatively heterogeneous population;  $30 < CV$  heterogeneous population.

For the arithmetic mean of the quantitative variables the confidence interval ( $CI_{95}$ ), with a safety level ( $p$ ) of 0.95 and significance level ( $\alpha$ ) of 0.05 was calculated.

$$CI_{95} = \bar{X} \pm z \times SE \quad (3)$$

Where:  $\bar{X}$  – arithmetic mean;  $z$  – value for a confidence interval of 95% (equal to 1.96);  $SE$  – standard average error.

$$SE = \frac{s}{\sqrt{n}} \quad (4)$$

Where:  $s$  – standard deviation;  $n$  – number of cases.

For that purpose the predefined Excel CONFIDENCE function was used, that determines the confidence interval  $z \times SE$ .

For comparison of the observed frequencies with the estimated frequencies the analysis of the qualitative variables frequency was performed using the non-parametric  $\chi^2$  test.

$$\chi^2 = \sum \frac{(f_o - f_e)^2}{f_e}$$

(5)

Where:  $\sum$  – sum;  $f_o$  – observed value;  $f_e$  – estimated value.

The measures of location were calculated using QUARTILE function: the first quartile ( $Q_1$ ); the second quartile ( $Q_2$ ); the third quartile ( $Q_3$ ); the interquartile range (IQR):  $Q_3 - Q_1$ .

For distribution of the variables and symmetry measurement, the predefined Excel SKEW function was used.

$$\alpha = \frac{\sum_{i=1}^n \left( \frac{X_i - \bar{X}}{s} \right)^3}{n}$$

(6)

Where:  $\sum$  – sum;  $X_i$  – individual value of the  $X$  variable;  $\bar{X}$  – arithmetic mean;  $s$  – standard deviation;  $n$  – number of cases;  $\alpha=0$  symmetric distribution;  $\alpha<0$  distribution with the tail to the right;  $\alpha>0$  distribution with the tail to the left.

For analysis of the dispersion, the one-way ANOVA for comparing the means of three or more independent samples was used.

By the calipers were measured the length and width of the FNT and by a protractor was measured the degree of its bifurcation angle. All the measurement have been taken by the same observer.

The cadavers belonged to the Department of anatomy and clinical anatomy of *Nicolae Testemitanu* State University of Medicine and Pharmacy of the Republic of Moldova.

## RESULTS

The mean length of the heads for MCT was  $194.21 \pm 4.85$ , for BCT –  $189.28 \pm 4.42$  and for DCT –  $195.71 \pm 4.01$ , statistically significant,  $p = 0.01$ .

In MCT the mean width of the heads was  $149.91 \pm 2.83$ , in BCT –  $152.30 \pm 3.22$  and in DCT –  $145.41 \pm 3.00$ , highly statistically significant,  $p = 0.000$ .

The cephalic index in mesocephalic individuals had a mean value of  $77.2097 \pm 1.03$ , in brachycephalic cadavers –  $80.4674 \pm 0.28$  and in dolichocephalic ones –  $74.3004 \pm 0.53$ , and a very high statistical significance was established,  $p = 0.0000$ .

A significant difference of the mean values of the head dimensions dependent on gender was established for all the variables (Table I).

Seven branching patterns of the facial nerve were established. Type I was determined in 18.7%, Type II – 14.7%, Type III – 20%, Type IV – 14.6%, Type V – 5.3%, Type VI – 18.7%, and Type-NI – 8%. The male/female ratio of the branching pattern for Type I was 20.3%/12.5%, Type II – 10.2%/31.3%, Type III – 23.7%/6.3%, Type IV – 13.6%/18.8%, Type V – 5.1%/6.3%, Type VI – 16.9%/25.0% and Type-NI was present only in male with a rate of 10.2%,  $p = 0.48$ .

For our purpose, the extratemporal part of the facial nerve was divided into three segments: the premandibular (FNT and its primary divisions), intraparotid (parotid plexus within the parotid gland) and postparotid (terminal divisions of the parotid plexus).

A range of peculiarities concerning FNT direction, number, length, width and angle of bifurcation were identified on the premandibular segment of the facial nerve.

Three main directions of the FNT were established: the descending, ascending and horizontal ones. The descending direction was marked out in 73.3%, the ascending one – in 9.3% and the horizontal – in 10.7%. Among the ascending FNT in 5.3% were determined very short diffuse branching trunks and in 1.3% an arch-shaped trunk was found (Figure 1).

All the directions of the FNT were characteristic for both male and female. The descending FNT had a male/female ratio of 69.5%/87.4%, the ascending – 10.2%/6.3% and the horizontal one – 11.9%/6.3%. Number variants constituted 8.4% and were found only in male.

The right/left ratio of the descending FNT was 62.9%/82.5%; ascending – 11.4%/7.5%; horizontal – 11.4%/10%, and in 14.3%, only on the right hemifaces, were determined numerical variants.

Dependent on the anthropometric type of the head, only in MCT were identified all the directions of the FNT. Thus, descending FNT was pointed out in 70.6%, and each of the ascending and horizontal positions were revealed in 12.1%. Numerical variants were found in 5.2% (Figure 1).

In brachycephalic individuals only descending direction of the FNT was established. In dolichocephalic cadavers the descending FNT was present in 66.7% of cases, in 11.1% it had a horizontal position, and no ascending facial nerve trunks were found. Number variants were determined in 22.2%. The  $\chi^2$  test for FNT direction dependent on anthropometric type of the head was not statistically significant,  $p = 0.25$ .

The mean length of the FNT in male was 11.3 mm (5-21 mm) and in female – 10.4 mm (5-16 mm),  $p = 0.289$ . A similar mean length of 11.1 mm was determined for both right (5-18 mm) and left (5-21 mm) hemifaces,  $p = 0.981$ . In mesocephalic cadavers the mean length of the FNT was  $10.9 \pm 2.87$ , in brachycephalic individuals –  $12.3 \pm 3.54$  and in dolichocephalic ones –  $10.9 \pm 2.54$ ,  $p = 0.474$ . The mean length of the FNT dependent on branching pattern for Type I was  $12.21 \pm 3.33$ , Type II –  $11.00 \pm 2.54$ , Type III –  $11.33 \pm 2.93$ , Type IV –  $10.27 \pm 3.85$ , Type V –  $11.50 \pm 2.08$ , Type VI –  $10.07 \pm 2.06$  and Type-NI –  $11.50 \pm 3.11$ ,  $p = 0.578$ .

The mean width of the FNT was 2.7 mm for both male (1.9-4.1 mm) and female (1.9-3.8 mm) cadavers,  $p = 0.629$ . The same mean value of 2.7 mm of the FNT width was established for both right (1.9-4.0 mm) and left (1.9-4.1 mm) hemifaces,  $p = 0.868$ . The width of the FNT was variable dependent on the anthropometric type of the head. In MCT the mean value was  $2.75 \pm$

0.49, in BCT –  $2.81 \pm 0.42$ , and in DCT –  $2.40 \pm 0.24$ ,  $p = 0.151$ . Dependent on branching pattern the mean width of the FNT varied as follows: Type I –  $2.71 \pm 0.49$ , Type II –  $2.64 \pm 0.37$ , Type III –  $2.70 \pm 0.31$ , Type IV –  $2.82 \pm 0.55$ , Type V –  $2.75 \pm 0.34$ , Type VI –  $2.71 \pm 0.57$  and Type-NI –  $2.95 \pm 0.80$ ,  $p = 0.950$ .

The curves of the central tendency and frequency of the FNT length and width distribution showed an asymmetry with the tail to the right (Figure 2).

The mean value of the FNT bifurcation angle in male was  $120.3^\circ$  ( $40^\circ$ - $180^\circ$ ) and in female –  $142.7^\circ$  ( $92^\circ$ - $180^\circ$ ), statistically significant,  $p = 0.050$ . The right/left ratio of the mean bifurcation angle was  $127.4^\circ$  ( $40^\circ$ - $180^\circ$ )/ $121.2^\circ$  ( $74^\circ$ - $180^\circ$ ),  $p = 0.483$ . In MCT the bifurcation angle had a mean of  $124.98^\circ \pm 34.17$ , in BCT –  $119.14^\circ \pm 41.37$ , and in DCT –  $123.89^\circ \pm 35.83$ ,  $p = 0.919$ . The bifurcation angle was statistically significant dependent on branching pattern,  $p = 0.005$  (Table II).

The bifurcation of the FNT was determined in 84% of cases, the trifurcation in 6.6%, the quadrifurcation in 2.7%, the pentafurcation in 4%, and the hexafurcation in 2.7%. In all the cases of the FNT numerical variation, the trunks were connected to each other and then bifurcated.

The numerical variants of the FNT were represented by double trunk in 5.3% and triple trunk in 1.3% (Figure 1). The mean value of the FNT number variation was 1.1 FNT,  $p = 0.261$ . On the right side the mean was 1.2 FNT, and on the left – 1.0 FNT,  $p = 0.019$ . Dependent on the anthropometrical type of the head the mean number of the FNT in MCT was  $1.07 \pm 0.32$ , in BCT –  $1.00 \pm 0.00$ , and in DCT –  $1.22 \pm 0.44$ ,  $p = 0.311$ . Dependent on branching pattern the mean value of the FNT number for Types I, IV, V and VI was  $1.00 \pm 0.00$ , and for the Types II, III and Type-NI were established the following mean values: Type II –  $1.09 \pm 0.30$ , Type III –  $1.20 \pm 0.56$ , Type-NI –  $1.33 \pm 0.52$ ,  $p = 0.192$ .

## DISCUSSION

The majority of papers that concern the facial nerve branching pattern are based on six types reported by Davis et al. [2]. Nevertheless, the branching pattern of the facial nerve includes a wider range of variation, thus, Pitanguy et al. [14] and Stankevicius et al. [18] have identified 8 branching patterns, 11 types were described by Kopuz et al. [8] and 12 types were established by Martínez Pascual et al. [10]. In the current study 14 types were determined, including atypical ones, initially classified as intermediate types [1], but finally redistributed and reclassified into 7 types.



Three main directions of the FNT were established in the current study and according to our observation they depended on variation of the mastoid segment of the facial canal, but it is not excluded, that those variants may even depend on variability of the stylomastoid foramen [5].

According to different sources, the length of the FNT is variable, thus, Wilhelmi et al. [20] reported a length between 5-15 mm, Kwak et al. [9] –  $13.0 \pm 2.8$  mm, Khoa et al. [7] – 14.1 mm, Salame et al. [16] –  $16.44 \pm 3.2$  mm, and the highest mean value of  $17.0 \pm 4.54$  mm was established by Pacheco-Ojeda et al. [13]. In our study the mean length of the FNT was  $11.1 \pm 0.7$  mm.

The width of the FNT as well is variable. According to Martínez et al. [10] the width is  $2.16 \pm 0.49$  mm, Khoa et al. [7] reported 2.5 mm and Salame et al. [16]  $2.66 \pm 0.55$  mm. In the current study the mean width was  $2.7 \pm 0.1$  mm.

Usually the FNT bifurcates into the temporofacial and the cervicofacial divisions [6, 10, 17]. Khoa et al. [7] obtained an angle of the FNT bifurcation of  $91.2^\circ$ . In our study the mean value in male was  $120.3^\circ$  and in female  $142.7^\circ$ ,  $p = 0.050$ .

In some cases a trifurcation, or even multifurcation of the FNT is found [7–9, 12, 18–19]. The reported incidence of the FNT bifurcation is about 80%, the trifurcation – 14% and numerical variants are found in 6% [8, 18–19]. In the current study the bifurcation of the FNT was established in 84% of cases (including 6.7% of number variation), trifurcation was established in 6.6% and multifurcation in 9.4% of cases. In cases of the facial canal dehiscence a double or triple FNT is present [8, 15, 19].

## CONCLUSIONS

Three directions were characteristic for the FNT: descending, ascending and horizontal ones. The descending FNT prevailed in female with a male/female ratio of 0.79:1. The ascending and horizontal directions of the FNT were higher in male individuals. For the ascending FNT the male/female ratio was 1.62:1, and for the horizontal one – 1.89:1. The highest rate of the FNT direction variability was characteristic for MCT and the lowest one for BCT. The descending FNT prevailed in all the anthropometric types. The length of the FNT was variable on all the examined criteria. The width of the FNT was the same for both genders and both sides of the head, but variable dependent on anthropometric type of the head and branching pattern. The angle of bifurcation was higher in female cadavers; on the right hemifaces; in MCT and in individuals with Type II branching pattern. The numerical variants were found only in male

cadavers and only on the right hemifaces, but they were variable dependent on anthropometric type of the head and pattern of branching.

### **Ethical consideration**

The protocol for the research project has been approved by the Ethics Committee of *Nicolae Testemitanu* State University of Medicine and Pharmacy of the Republic of Moldova (minute No.1 of 15.09.2014), and it was conducted at the Department of anatomy and clinical anatomy in full accordance with the Declaration of Helsinki.

**Conflict of interest:** None declared

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**Table I.** The mean values of the dimensions of the head dependent on gender

	Length of the head (mm)	Width of the head (mm)	Cephalic index
Male	195.5	150.3	76.9
Female	188.0	147.2	78.3
Difference	7.5	3.1	-1.4
p – value	0.000	0.001	0.004

**Table II.** Angle of the FNT bifurcation dependent on facial nerve branching pattern

Type of branching	Mean value ± SD	Mean value ± CI <sub>95%</sub>
Type I	103.7° ± 23.67	103.7° ± 13.39
Type II	156.8° ± 29.24	156.8° ± 17.28
Type III	125.4° ± 37.97	125.4° ± 21.49
Type IV	108.7° ± 25.78	108.7° ± 15.98
Type V	135.7° ± 22.50	135.7° ± 25.46
Type VI	118.5° ± 35.03	118.5° ± 20.70
Type-NI	135.4° ± 36.16	135.4° ± 31.70

**Figure 1.** Morphological variability of the facial nerve trunk on the premandibular segment. (A) – descending trunk; (B) – ascending trunk; (C) – horizontal trunk; (D) – very short diffuse branching trunk; (E) – arch-shaped trunk; (F) – triple trunk: 1 – superior trunk, 2 – middle trunk, 3 – inferior trunk; (G, H, I) – double trunk: AT – anterior trunk, PT – posterior trunk; ST – superior trunk, IT – inferior trunk.

**Figure 2.** Curves of the central tendency and frequency distribution of the FNT length and width.



