Research Article

Anatomical causes of Costen's syndrome

Ivan V. Gaivoronskiy[1], Alexander V. Tscymbalystov[2], Maria G. Gaivoronskaya[3]*, Irina V. Voytyatskaya[2], Vladimir K. Leontiev[2], Sergey Y Ivanov[2]

ABSTRACT

On 108 skulls specimens with malocclusion and 30 skulls specimens with complete edentulism from the craniological collection of the Department of Normal Anatomy of the Military Medical Academy named after S.M. Kirov, a comprehensive study of the morphometric characteristics of the articular surfaces of TMD joint was carried out. The peculiarities of petrotympanic fissure topography in various forms of the brain skull were also evaluated to establish the possible anatomical causes of Costen's syndrome. The fact of the variability of the petrotympanic fissure topography within the mandibular fossa has been established, the fissure can be located in back and mesial parts of this fossa or it takes intermediate position. The option of petrotympanic fissure topography in mesial parts of the mandibular fossa is a predisposing anatomical factor for Costen's syndrome and can be found at different neurocranium forms but predominantly at hypsicranial. The immediate cause of the Costen's syndrome can be occlusal-caused diseases followed by TMD joint dysfunction. In this case, the changes of articular surface of TMD joint take place, in particular, a decrease in size of the head of mandible, its pathological displace, capsule stretching, and compression of chorda tympani.

KEY WORDS: Articular head, Brain skull, Chorda tympani, Costen's syndrome, Dysfunction, Mandibular fossa, Petrotympanic fissure, Temporomandibular joint

INTRODUCTION

Temporomandibular joint dysfunction (TMD, TMJD) is one of the most common dental diseases. The study of the prevalence of TMD in our country and abroad found a significant variability - from 12 to 75%.[1-5] Most researchers hold a theory of multifactorial nature of TMJD. At the same time, many authors agree that the occurrence of TMJD is largely due to such predisposing causes as anatomical features of the structure of this joint. However, the individual characteristics of TMJ structure (a significant difference in the shape of the mandibular fossa and the head of mandible, the non-significance of the mandibular fossa, the small size of the head of mandible, and the flattened or stressed convex-concave shape of the articular disc) significantly exacerbate the course of dysfunction if there are any etiologic factors.[6,7]

Costen's syndrome characterized by unilateral or bilateral hearing loss, ear fullness, burning sensation of the tongue, and dull ache in the ears, eyes, etc., is defined as one of the symptoms of TMJ dysfunction. Possible etiologic factors that lead to these symptoms are the morphological peculiarities of petrotympanic fissure topography, through which the chorda tympani exits,[8] which supplies the innervation of taste buds in the anterior two-thirds of the tongue, sublingual, submandibular gland, and minor salivary glands of the tongue.

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Study Purpose

The purpose of this study was to identify the main anatomical causes of Costen's syndrome.

The following objectives have been set out in the presented part of the study:

1. To conduct a morphometric analysis of the articular surfaces of TMD joint in adults with different neurocranium forms.
2. To conduct a morphometric analysis of the articular surfaces of TMD joint in adults with varying degrees of the preservation of the dentition.
3. To study the peculiarities of petrotympanic fissure topography.

[1]Military Medical Academy Named After S.M. Kirov 194044 St. Petersburg, Academician Lebedev Street., 6, Russia, [2]Department of Dentistry, Belgorod State University 308000, Belgorod, Russia, [3]Department of Morphology, St. Petersburg State University 199034 St. Petersburg, Universitetskaya Embankment 7/9, Russia

***Corresponding author:** Maria G. Gaivoronskaya, Department of Morphology, St. Petersburg State University 199034 St. Petersburg, Universitetskaya Embankment 7/9, Russia. E-mail: solnushko12@mail.ru

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MATERIALS AND METHODS

The study object included 108 certified skulls with lower jaws with malocclusion and 30 fully edentulous skulls.

Craniometry

Measurements of the skull were performed between the standard craniometric points,[1] and for the parameters studied, characterizing the articular surfaces of TMJ and the distance to petrotympanic fissure, a number of non-standard craniometric measurements determined from a standard craniometric formations to the middle of the fissure were also proposed.

The following parameters were measured to study the characteristics of TMD joint articular surfaces: (1) Length of the mandibular fossa, (2) width of the mandibular fossa, (3) length of the eminentia articularis, (4) width of the eminentia articularis, (5) length of the condyloid process, (6) width of the condyloid process, (7) depth of the mandibular fossa, and (8) length of the petrotympanic fissure.

The followings were measured to study the petrotympanic fissure topography: (1) The distance from the middle of the petrotympanic fissure to mastoidale, (2) the distance from the middle of the petrotympanic fissure to the porion point, (3) the distance from the middle of the petrotympanic fissure to auricular point, (4) the distance from the middle of the petrotympanic fissure to zygomaxillary point, (5) the distance from the middle of the petrotympanic fissure to foramen ovale, (6) the distance from the middle of the petrotympanic fissure to the external opening of carotid canal, (7) the distance from endogonion point to petrotympanic fissure, (8) the distance from the lateral border of the petrotympanic fissure to the external opening of carotid canal, (9) the distance from the lateral border of the petrotympanic fissure to the zygion point, and (10) the distance from the medial margin of the petrotympanic fissure to the zygion point.

Two cephalic indices were used to organize the skulls. The first is a ratio of the transverse diameter of the skull to the longitudinal. Categories of this index are referred to dolichocephalic, mesaticephalic, and brachycephalic. The second index is a ratio of the altitude diameter of the skull to the longitudinal. Categories of this index are referred to platycrania, orthocrania, and hypsicrania.

Cranioscopy

The cranioscopic part of the study has evaluated the position of the petrotympanic fissure relative to the mandibular fossa. In the case of petrotympanic fissure passing along the posterior edge of the mandibular fossa, the petrotympanic fissure topography was regarded as the first option, in the case of fossa intersecting at the medial third - as the second option.

Statistical Methods

Statistical analysis of the data obtained was carried out using the Statistica 7.0 application package. For each measure, the arithmetic mean and the arithmetic mean error were defined. To identify the differences between the average values at the contralateral sides, the Student's t-test significance level was determined.

RESULTS AND DISCUSSION

It has been established that among skulls with malocclusion, there were 40 dolichocranial skulls, 34 - mesocranial, and 34 - brachycranial. In the case of altitude-longitudinal index classification, the overall sample was divided into 36 platycranial skulls, 40 orthocranial, and 32 hypsicranial.

It has been established that there are significant ($P < 0.05$) differences between mesocranial and brachycranial in width of the eminentia articularis and the cranial base length. Of the parameters characterizing the petrotympanic fissure topography, only the distance from the lateral border of the petrotympanic fissure to the external opening of carotid canal was significantly more pronounced in the dolichocranial group compared to the mesocranial group. There were no differences in the other dimensions characterizing the petrotympanic fissure topography or the anatomical structure of the articular surfaces of TMJ [Table 1].

It was found that cranial shaping determined by the value of the transverse-longitudinal index does not affect the morphometric characteristics of the articular surfaces of TMJ and the petrotympanic fissure topography. There are statistically significant differences between platycrania, orthocrania, and hypsicrania in the group of skulls classified by the value of the altitude-longitudinal index according to three parameters characterizing the petrotympanic fissure topography. In this case, the distance from endogonion point to petrotympanic fissure was significantly higher in the hypsicranial group; the distance from the medial margin of the petrotympanic fissure to the zygion point was, on the contrary, significantly higher in the platycranial group of skulls [Table 2].

It has been established that the petrotympanic fissure topography also varies according to the skulls belonging to the platycranial, orthocranial, or hypsicranial group. For instance, in orthocranial group, the most common option of its position was not determined. In almost the same number of cases,

Table 1: Craniometric parameters of the dolichocephalic, mesocephalic, and brachycephalic with malocclusion, mm ($X \pm m_x$)

Parameter	Dolichocephalic	Mesocephalic	Brachycephalic
Length of the mandibular fossa	24.2±0.5	24.6±0.6	24.6±0.6
Width of the mandibular fossa	13.7±0.5	14.2±0.4	13.6±0.5
Length of the articular tubercle	19.2±0.4	19.4±0.6	19.4±0.6
Width of the articular tubercle	9.3±0.3	10.2±0.4	8.9±0.4**
Length of the condyloid process	19.7±0.4	19.0±0.8	20.1±0.4
Width of the condyloid process	8.6±0.3	8.4±0.3	8.1±0.2
Depth of the mandibular fossa	8.6±0.4	8.8±0.5	8.6±0.4
Length of the petrotympanic fissure	15.2±0.7	14.6±0.9	15.2±0.9
The distance from the middle of the petrotympanic fissure to mastoidale	32.1±0.8	32.8±0.7	32.7±0.7
The distance from the middle of the petrotympanic fissure to the porion point	21.8±0.7	22.3±0.5	22.6±0.5
The distance from the middle of the petrotympanic fissure to auricular point	22.9±0.7	22.8±0.6	24.5±0.5
The distance from the middle of the petrotympanic fissure to zygomaxillary point	61.8±1.3	59.6±1.1	60.0±0.9
The distance from the middle of the petrotympanic fissure to foramen ovale	16.1±0.6	16.2±0.5	16.5±0.5
The distance from the middle of the petrotympanic fissure to the external opening of carotid canal	10.4±0.5	10.2±0.6	9.8±0.6
The distance from endogonion point to petrotympanic fissure	59.5±1.3	60.4±1.6	59.1±1.4
The distance from the lateral border of the petrotympanic fissure to the external opening of carotid canal	16.7±0.5**	14.8±0.6*	15.8±0.8
The distance from the lateral border of the petrotympanic fissure to the zygion point	31.6±0.9	32.5±1.0	29.8±0.7
The distance from the medial margin of the petrotympanic fissure to the zygion point	37.2±0.8	38.1±0.9	36.4±0.6

*–differences with the dolichocephalic; **–with the mesocephalic ($P<0.05$)

Table 2: Craniometric parameters of the platycrania, orthocrania, and hypsicrania with malocclusion, mm ($X \pm m_x$)

Parameter	Platycrania	Orthocrania	Hypsicrania
Length of the mandibular fossa	24.9±0.6	24.7±0.3	23.6±0.7
Width of the mandibular fossa	14.1±0.5	14.1±0.4	13.2±0.5
Length of the articular tubercle	19.1±0.6	19.6±0.5	19.2±0.4
Width of the articular tubercle	9.6±0.5	9.5±0.3	9.4±0.4
Length of the condyloid process	20.3±0.5	19.2±0.6	19.4±0.5
Width of the condyloid process	8.5±0.3	8.2±0.2	8.4±0.4
Depth of the mandibular fossa	8.4±0.4	8.5±0.4	9.2±0.5
Length of the petrotympanic fissure	15.7±1.2	15.2±0.7	14.1±0.7
The distance from the middle of the petrotympanic fissure to mastoidale	32.0±0.8	32.9±0.8	32.6±0.6
The distance from the middle of the petrotympanic fissure to the porion point	21.8±0.6	22.7±0.5	22.2±0.6
The distance from the middle of the petrotympanic fissure to auricular point	23.4±0.7	23.6±0.5	23.1±0.7
The distance from the middle of the petrotympanic fissure to zygomaxillary point	59.9±1.7	60.3±0.8	61.6±0.9
The distance from the middle of the petrotympanic fissure to foramen ovale	16.3±0.5	16.6±0.5	15.9±0.6
The distance from the middle of the petrotympanic fissure to the external opening of carotid canal	10.4±0.4	10.3±0.5	9.6±0.7
The distance from endogonion point to petrotympanic fissure	59.6±1.8	57.9±1.2	61.7±1.3**
The distance from the lateral border of the petrotympanic fissure to the external opening of carotid canal	15.9±0.5	16.2±0.6	15.2±0.8
The distance from the lateral border of the petrotympanic fissure to the zygion point	32.9±0.9	30.4±0.9	30.7±0.8
The distance from the medial margin of the petrotympanic fissure to the zygion point	38.6±0.9**	36.8±0.8	36.2±0.6*
Width of the foramen magnum	29.4±0.6	28.8±0.6	29.9±0.6

*–differences with the dolichocephalic; **–with the mesocephalic ($P<0.05$)

the petrotympanic fissure was located along the posterior edge of the mandibular fossa [Figure 1] or passed through medial third of the mandibular fossa [Figure 2]. The second option of the petrotympanic fissure topography is more commonly found as part of the hypsicranial group, and the first option - as part of the platycranial group.

It can be believed that for option 2 of the petrotympanic fissure topography, the chorda tympani may be

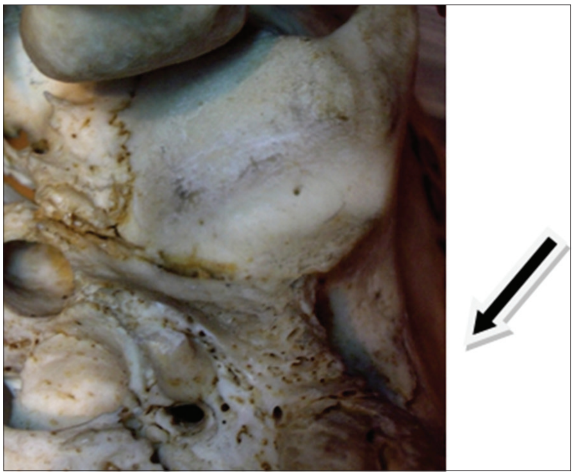

Figure 1: Petrotympanic fissure passing through the posterior edge of the mandibular fossa (arrow). External base of skull (bottom view)

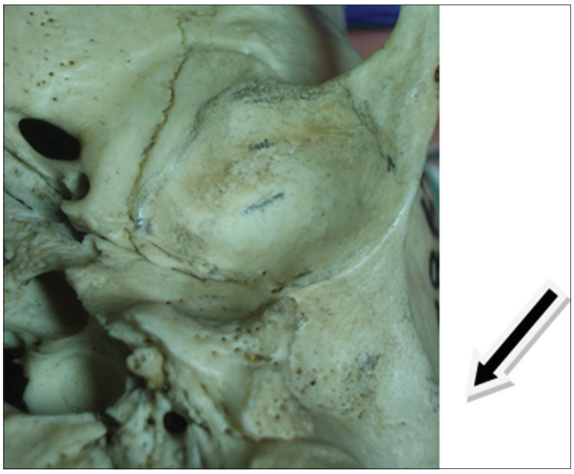

Figure 2: Petrotympanic fissure passing through the medial third of the mandibular fossa (arrow). External base of skull (bottom view)

irritated or damaged. Accordingly, the development of Costen's syndrome is predominantly typical for hypsicrania. However, given the possibility of the first option of the petrotympanic fissure topography, Costen's syndrome can develop in each of the studied shapes of the skull. No significant differences with regard to the parameter characterizing the location of the petrotympanic fissure relative to the mandibular fossa have been found in the distribution of skulls by transverse-longitudinal index.[9]

The comparative morphometric analysis of the parameters from skulls with malocclusion and with complete edentulism revealed statistically significant differences in some sizes of TMJ articular surfaces [Table 3].

Table 3 shows that the parameters characterizing the mandibular fossa, eminentia articularis, and the head of mandible change statistically significant with the loss of teeth. Changes of articular surfaces in the occlusion-caused diseases result in severe forms of TMJ dysfunction, stretching of its capsule, and compression of the chorda tympani within the petrotympanic fissure.

According to Trezubov,[10] the development of Costen's syndrome is explained by the involvement of the border areas with the joint, in particular, the irritation of chorda tympani, tympanic plexus, blockage of the eustachian tubes caused by vascular disorders, and neurovascular injury that passes through the petrotympanic fissure.

Badanin[2] and Semenyuk and Leontyev[11] note that the most common cause of dysfunction is the partial absence of teeth or odontatrophia, which leads to a decrease in the interalveolar distance. The data show

Table 3: Craniometric parameters of skulls with malocclusion and with complete edentulism, mm ($X \pm m_x$)

Parameter	Malocclusion	Complete edentulism
Length of the mandibular fossa	23.8 ± 0.6	24.7 ± 0.5
Width of the mandibular fossa	15.2 ± 0.3	15.1 ± 0.6
Length of the articular tubercle	18.1 ± 0.6	15.0 ± 0.7*
Width of the articular tubercle	9.6 ± 0.5	7.1 ± 0.5*
Length of the condyloid process	20.1 ± 0.4	16.2 ± 0.6*
Width of the condyloid process	9.5 ± 0.3	7.0 ± 0.2*
Depth of the mandibular fossa	9.4 ± 0.4	7.3 ± 0.6*
Length of the petrotympanic fissure	16.1 ± 1.2	15.9 ± 0.7
The distance from the middle of the petrotympanic fissure to mastoidale	31.9 ± 0.8	32.3 ± 0.8
The distance from the middle of the petrotympanic fissure to the porion point	22.0 ± 0.4	22.7 ± 0.7
The distance from the middle of the petrotympanic fissure to auricular point	24.3 ± 0.7	23.9 ± 0.6
The distance from the middle of the petrotympanic fissure to zygomaxillary point	58.9 ± 1.1	60.1 ± 1.4
The distance from the middle of the petrotympanic fissure to foramen ovale	15.4 ± 0.5	16.1 ± 0.5
The distance from the middle of the petrotympanic fissure to the external opening of carotid canal	14.2 ± 0.5	13.3 ± 0.5
The distance from endogonion point to petrotympanic fissure	60.6 ± 1.2	59.9 ± 1.8
The distance from the lateral border of the petrotympanic fissure to the external opening of carotid canal	14.9 ± 0.4	16.7 ± 0.7
The distance from the lateral border of the petrotympanic fissure to the zygion point	30.9 ± 0.7	30.4 ± 0.9
The distance from the medial margin of the petrotympanic fissure to the zygion point	37.7 ± 0.7	36.8 ± 0.9
Width of the foramen magnum	30.4 ± 0.6	32.8 ± 0.6

*–$P<0.05$

that TMJ dysfunction is diagnosed in more than half of persons (62.5%) with dentition defects.[8]

Rabukhina *et al*.[8] pointed out that in the absence of teeth, the head of mandible shifts posteriorly, while there is a moment of compression in the joint to the retroarticular space, where there is a compression of anatomical formations located there.

If the petrotympanic fissure is located in the medial third of the mandibular fossa, it seems that there will be chorda tympani compression on a more frequent basis and, accordingly, the development of Costen's syndrome, then in case of its location on the posterior edge of the mandibular fossa.

CONCLUSIONS

1. The option for the location of the petrotympanic fissure in mesial parts of the mandibular fossa, which is a predisposing anatomical factor for Costen's syndrome, can be found at different neurocranium forms, but predominantly at hypsicranial.
2. The immediate cause of the Costen's syndrome can be occlusal-caused diseases followed by TMJD. In this case, the changes of the articular surface of TMD joint take place, in particular, a decrease in size of the head of mandible, its pathological displace, capsule stretching, and compression of chorda tympani.

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