Morphometric and Topographic Features of Stylomastoid Foramen and its Clinical Significance in Facial Nerve Block

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Abstract

Objective This study aims to determine the topographic localization of the stylomastoid foramen (SF) and its morphometric relationship with the surrounding bony landmarks.

Design A descriptive anatomical study.

Setting Anatomy Laboratory of the Faculty of Medicine.

Participants Measurements were performed on 53 dry temporal bones.

Main Outcome Measures On the inferior and lateral aspects of photographic images, lines and angles were defined. The most lateral end of the SF (SF1) and the transverse medial–lateral line that passes through the upper end of the anterior border of mastoid process (line 1) were used as reference points for topographic evaluation. The upper end of the anterior border of mastoid process (A) and the tip of mastoid process (B) were considered in defining angles. The dates about SF were evaluated using the ImageJ 1.46r software and digital caliper.

Results SF1 was classified into three different types based on its topographical localization, stated as Type 1, Type 2, and Type 3. In Type 1, SF1 was located anterior to line 1 (54.7%). SF1 was located posterior to line 1 in Type 2 (34.0%). SF1 was located just over line 1 in Type 3 (11.3%). We also detected angular variations between these types in the inferior and lateral aspects.

Conclusion The recommended angles of application are 30 degrees on the horizontal plane and 55 degrees on the sagittal plane for Type 1 when point B is considered. A needle length below 10 mm is more suitable to minimize the potential complications of the nerve block.

Keywords

- stylomastoid foramen
- Nadbath block
- morphometry

Introduction

The facial nerve is blocked in safe ophthalmologic surgery[1] and in the treatment of involuntary clonic and tonic movements (hemifacial spasm) in one-half of face.[2] Several facial nerve block techniques have been employed in clinical practice. The facial nerve block techniques are performed according to the topographic locations of the facial nerve or its ramifications.[1,3] *Nadbath facial nerve block* is one of the methods that have been used in facial nerve blocks.[4] In this method, the trunk of the facial nerve is blocked at the level that it exits the *stylomastoid foramen* (SF) before entering the

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parotid gland, and temporary palsy occurs in the facial muscles. In this method, anatomical bony landmarks such as the mastoid process (MP) and the posterior border of the mandibular ramus are considered. In the Nadbath block, the needle is inserted perpendicular to the skin, 1 to 2 mm anterior to the anteriosuperior border of the MP.[4–6] Prolonged facial paralysis,[7] dysphagia and respiratory distress,[8] and vocal cord paralysis[9] are complications that have been reported after Nadbath block.

The SF is the emerging point of the facial nerve from the skull base. It is located lateral to the inferior aspect of the temporal bone between the MP and styloid process.[10] It is important to have knowledge on the morphometric and topographic characteristics of the SF and its relationship with bony landmarks to minimize the neural complications that may result from a Nadbath block. However, there are not enough studies in the literature to examine the topographic and morphometric characteristics of SF and provide reference data for Nadbath block. The purpose of this study is to determine the topographic localization of the SF and its morphometric relationship with the surrounding bony landmarks.

Methods

This descriptive observational study included a total of 53 dry adult temporal bones (25 right, 28 left) examined in Anatomy Laboratory, Faculty of Medicine, Istanbul Medeniyet University, Istanbul, Turkey. Of the 53 temporal bones, 32 were on the skulls (on 16 skulls) and 21 were separate. Damaged bones were excluded from the study. To standardize photography, the portion of the zygomatic process closest to the temporal squamous was referenced and positioned as parallel to the horizontal plane as possible. The inferior and lateral aspects of the temporal bones were photographed at same distance using a digital camera (Canon SX500-IS).

On digital images, angular and morphometric measurements were performed using the ImageJ 1.46r software. An electronic digital caliper was used for direct morphometric measurements. All morphometric measurements were performed by the same author.

The Lines and Angles Defined on the Inferior Aspect

On the inferior aspect, the most lateral end of SF (point SF1) was marked. The lines and angles on this aspect are defined below.

Line 1: The transverse medial–lateral line that passes through the upper end of the anterior border of the MP (point A) parallel to the ground.

Line 2: The oblique line that passes through the upper end of the anterior border of the MP (point A) and the inferior projection of SF1 parallel to the ground.

Line 3: The transverse medial–lateral line that passes through the tip of the MP (point B) parallel to the ground.

Line 4: The oblique line that passes through the tip of the MP (point B) and the inferior projection of SF1 parallel to the ground.

On this aspect, the angle between Line 1 and Line 2 (*Angle 1*) and the angle between Line 3 and Line 4 (*Angle 2*) were measured (►**Fig. 1**).

The Lines and Angles Defined on the Lateral Aspect

On the lateral aspect, the lateral projection of the most lateral end of the SF (point X) was marked by a felt pen to match the inferior aspect's level. The lines and angles are defined below.

Line 5: The anterior–posterior line that passes through the tip of the MP (point B) parallel to the ground.

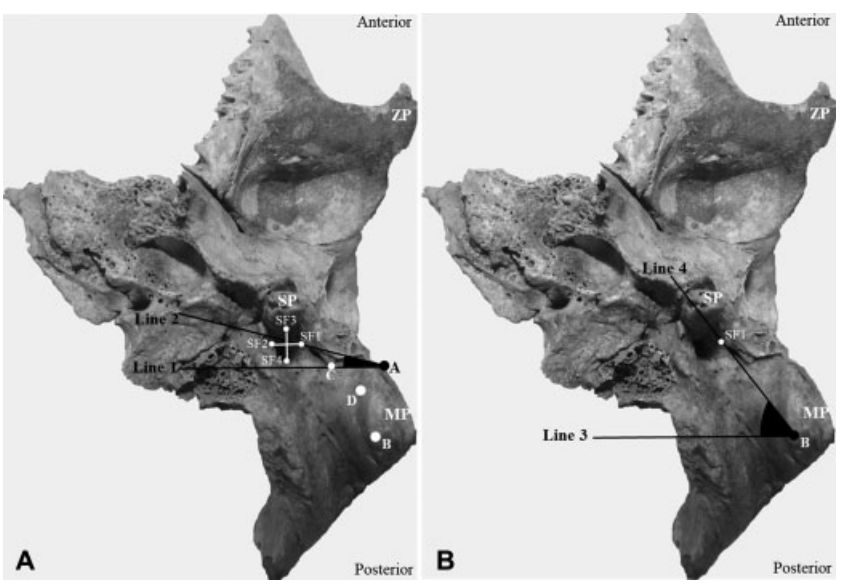

Fig. 1 The defined lines, reference points, and angles on *left temporal bone* on inferior aspect. (**A**) Line 1, Line 2, Angle 1, and morphometric reference points on inferior aspect. (**B**) Line 3, Line 4, and Angle 2 on inferior aspect; SF1: The most lateral end of the stylomastoid foramen; SF2: The most medial end of stylomastoid foramen; SF3: The most anterior end of stylomastoid foramen; SF4: The most posterior end of stylomastoid foramen. A: The upper end of anterior border of mastoid process; B: The tip of mastoid process; C: The medial end of tympanomastoid fissure; D: The anterior end of mastoid notch. MP, mastoid process; SP, styloid process; ZP, zygomatic process.

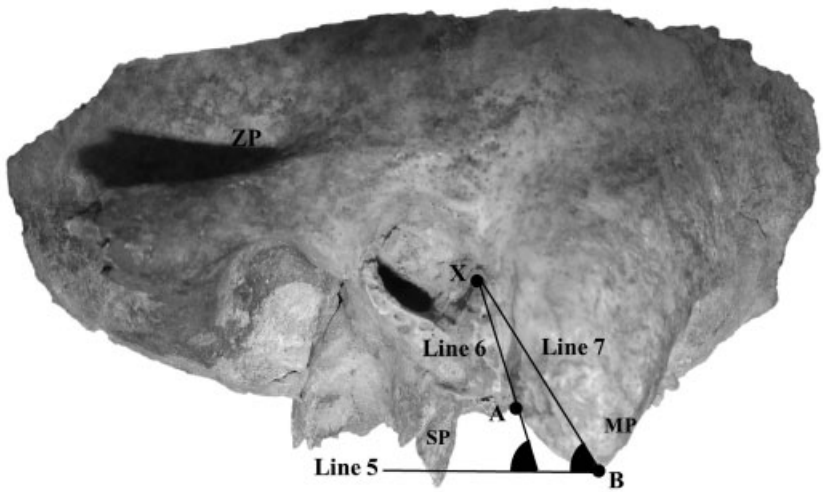

Fig. 2 The defined lines, reference points, and angles on left temporal bone on lateral aspect. A: The upper end of anterior border of mastoid process; B: The tip of mastoid process; X: The lateral projection of the most lateral end of the stylomastoid foramen. SP, styloid process; ZP, zygomatic process.

Line 6: The line that passes through the upper end of the anterior border of MP (point A) and the lateral projection of the most lateral end of the SF (point X).

Line 7: The line that passes through the tip of the MP (point B) and the lateral projection of the most lateral end of the SF (point X).

The angle between Line 5 and Line 6 (*Angle 3*), and the angle between Line 5 and Line 7 (*Angle 4*) were measured (►**Fig. 2**).

Morphometric Measurements on Inferior Aspect

The morphometric measurements listed below were performed on the inferior aspect and the distances were recorded as millimeter (►**Fig. 1**).

1. The distance between the most lateral end (SF1) and the most medial end (SF2) of the SF (SF1-SF2).
2. The distance between the most anterior end (SF3) and the most posterior end (SF4) of the SF (SF3-SF4).
3. The distance between the most lateral (SF1), the most medial (SF2), the most anterior (SF3), the most posterior (SF4) ends of the SF, and the upper end of the anterior border of the MP (point A) (SF1-A; SF2-A; SF3-A; SF4-A).
4. The distance between the most lateral (SF1), the most medial (SF2), the most anterior (SF3), the most posterior (SF4) ends of the SF, and the tip of the MP (point B) (SF1-B; SF2-B; SF3-B; SF4-B).
5. The distance between the most lateral (SF1), the most medial (SF2), the most anterior (SF3), the most posterior (SF4) ends of the SF, and the medial end of the tympanomastoid fissure (point C) (SF1-C; SF2-C; SF3-C; SF4-C).
6. The distance between the most lateral (SF1), the most medial (SF2), the most anterior (SF3), the most posterior (SF4) ends of the SF, and the anterior end of the mastoid notch (point D) (SF1-D; SF2-D; SF3-D; SF4-D).
7. The area of the SF (mm^2).

The data were analyzed and interpreted using the SPSS 22.0 for Windows software by cross-tabulations. Frequencies and percentages were provided for categorical data. Means and standard deviations were provided for the normally distributed data, or median and range for data belonging to groups with a small sample size. The data were compared using the Student's *t*-test for normally distributed data and the Mann–Whitney *U* test for nonnormally distributed data. The Pearson's correlation analysis was used for the correlation analyses.

Results

On temporal bones, it was observed that SF1 was topographically located in three different types according to Line 1. In Type 1, which was also the most frequent type, SF1 was located anterior to Line 1 (54.7%). SF1 was located posterior to Line 1 in Type 2 (34.0%). SF1 was located just over Line 1 in Type 3 (11.3%) (►**Fig. 3**; ►**Table 1**).

The results obtained from the morphometric measurements are provided in ►**Table 2** for individual types and in total. The mean distance (mm) between SF1 and SF2 was determined for Type 1, Type 2, and Type 3 as 3.03 ± 0.81 (min: 1.91, max: 5.20), 3.22 ± 1.11 (min: 1.82, max: 5.16), and 1.92 (min: 1.69, max: 4.15), respectively. The mean distance (mm) between SF3 and SF4 was measured as 3.03 ± 0.92 (min: 1.64, max: 4.71) for Type 1, 3.40 ± 1.14 (min: 1.71, max: 5.96) for Type 2, and 1.96 (min: 1.32, max: 6.27) for Type 3. There was a significant positive correlation between the distances between SF1–SF2 and SF3–SF4 ($r = 0.64$; $p = 0.01$).

The distance between SF3 and A was significantly different between the Type 1 and Type 2 groups ($p = 0.011$; t: 2.641). No statistically significant difference was found between the groups with regard to the other morphometric measurements ($p > 0.05$).

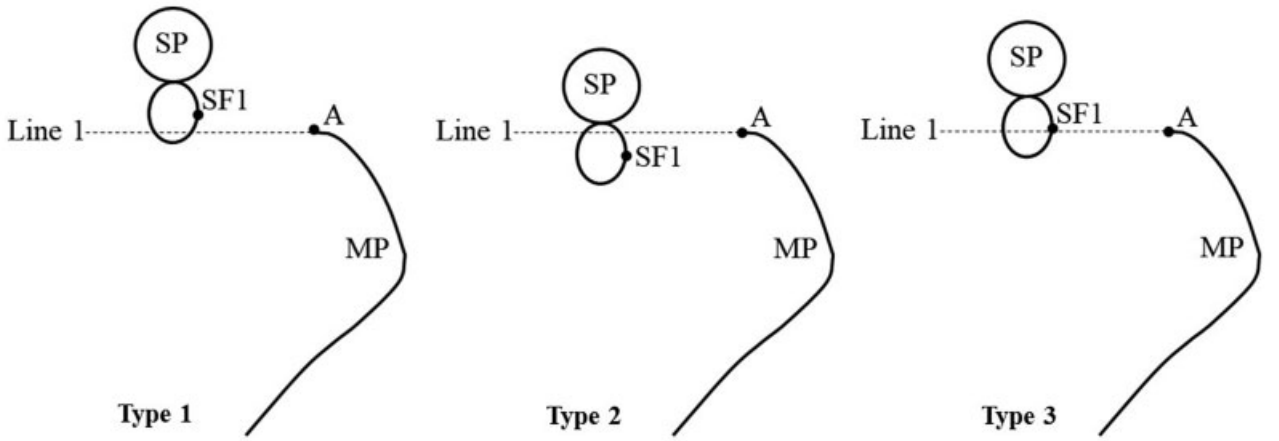

Fig. 3 The types of stylomastoid foramen were detected by localization of SF1 to Line 1 on the left side. SF1: The most lateral end of the stylomastoid foramen; A: The upper end of anterior border of mastoid process; Line 1: The transverse medial–lateral line that passes through the upper end of anterior border of mastoid process parallelly to the ground. MP, mastoid process; SP, styloid process.

Table 1 The topographic localizations of SF1 according to Line 1 on inferior aspect

Types	Right		Left		Total	
	n	%	*n*	%	*n*	%
Type 1	13	24.5	16	30.2	29	54.7
Type 2	8	15.1	10	18.9	18	34.0
Type 3	4	7.5	2	3.8	6	11.3

Note: SF1: The most lateral end of the stylomastoid foramen. Line 1: The transverse medial–lateral line that passes through the upper end of anterior border of mastoid process parallelly to the ground.

Table 2 The morphometric measurement results in three types and total on inferior aspect

The distances between anatomical landmarks (mm)	Type 1 ($n = 29$) (mean ± SD)	Type 2 ($n = 18$) (mean ± SD)	Type 3[a] ($n = 6$) Median (range)	Total ($n = 53$) (mean ± SD)
SF1–SF2	3.03 ± 0.81	3.22 ± 1.11	1.92 (1.69–4.15)	3.03 ± 0.97
SF3–SF4	3.03 ± 0.92	3.40 ± 1.14	1.96 (1.32–6.27)	3.13 ± 1.13
SF1-A	9.64 ± 1.99	8.77 ± 2.67	8.14 (5.02–11.77)	9.19 ± 2.33
SF2-A	12.27 ± 2.24	11.35 ± 2.31	11.48 (8.15–13.87)	11.84 ± 2.66
SF3-A	12.74 ± 2.52	10.74 ± 2.50	10.36 (8.36–13.81)	11.84 ± 2.66
SF4-A	9.95 ± 2.04	9.57 ± 2.13	9.73 (6.54–11.86)	9.74 ± 2.04
SF1-B	15.71 ± 3.18	15.64 ± 2.60	15.66 (12.79–19.92)	15.71 ± 2.91
SF2-B	17.46 ± 3.52	17.25 ± 2.85	17.32 (16.21–21.87)	17.47 ± 3.14
SF3-B	17.55 ± 3.02	17.19 ± 2.91	18.36 (15.63–20.26)	17.51 ± 2.83
SF4-B	15.01 ± 2.91	14.91 ± 2.45	14.51 (11.22–18.78)	14.99 ± 2.71
SF1-C	4.32 ± 1.88	3.70 ± 2.01	3.84 (2.15–5.27)	4.03 ± 1.85
SF2-C	7.36 ± 2.05	6.62 ± 1.83	5.75 (3.34–7.98)	6.93 ± 1.97
SF3-C	6.96 ± 2.25	5.97 ± 2.04	5.88 (5.05–8.69)	6.54 ± 2.12
SF4-C	5.34 ± 1.45	4.98 ± 1.76	4.59 (3.07–5.89)	5.13 ± 1.53
SF1-D	6.81 ± 2.93	6.63 ± 2.21	5.75 (4.68–7.25)	6.64 ± 2.52
SF2-D	7.56 ± 2.72	7.16 ± 2.01	6.60 (3.19–8.14)	7.28 ± 2.41
SF3-D	8.77 ± 2.70	8.39 ± 2.33	7.40 (4.87–10.07)	8.49 ± 2.49

Table 2 (*Continued*)

The distances between anatomical landmarks (mm)	Type 1 ($n = 29$) (mean ± SD)	Type 2 ($n = 18$) (mean ± SD)	Type 3[a] ($n = 6$) Median (range)	Total ($n = 53$) (mean ± SD)
SF4-D	5.40 ± 2.53	5.29 ± 2.18	3.95 (2.29–5.50)	5.21 ± 2.31
Area of stylomastoid foramen (mm^2)	8.96 ± 5.15	10.18 ± 5.75	3.32 (2.42–21.15)	9.09 ± 5.61

Abbreviation: SD, standard deviation.
Notes: SF1: The most lateral end of the stylomastoid foramen.
SF2: The most medial end of stylomastoid foramen.
SF3: The most anterior end of stylomastoid foramen.
SF4: The most posterior end of stylomastoid foramen.
(A) The upper end of anterior border of mastoid process; (B) the tip of mastoid process; (C) the medial end of tympanomastoid fissure; (D) the anterior end of mastoid notch.
[a]Because of the small sample or nonnormal distribution of data in the Type 3 group, data were presented as the median and range.

On inferior aspect, the angle between Line 1 and Line 2 (Angle 1) was anterior to Line 1 in Type 1, and was posterior to Line 1 in Type 2. In Type 3, the Angle 1 was zero (0 degree) because SF1 was exactly on Line 1 (Line 1 and Line 2 overlapped). On this aspect, the angle between Line 3 and Line 4 (Angle 2) was anterior to Line 3 for all temporal bones (►**Table 3**).

On lateral aspect, the angle between Line 5 and Line 6 (Angle 3) was smaller than 90 degrees in Type 1. The Angle 3 was greater than 90 degrees in Type 2. The angle between Line 5 and Line 6 was calculated as 90 degrees as points (A) and (X) lied on the same line in Type 3 (Line 3 and Line 4 were intersected perpendicularly). The angle between Line 5 and Line 7 (Angle 3) was smaller than 90 degrees in all temporal bones (►**Table 3**).

Discussion

There are several techniques of performing a facial nerve block. O'Brien's,[11] Van Lint's,[12] and Atkinson's[13] techniques have been utilized to induce effective lid akinesia in historical process. Different injection sites should be considered based on facial nerve branching. The *Nadbath facial nerve block* was defined in the year 1963 by Nadbath and Rehmani.[4] In this method, the facial nerve trunk, which is 15 mm deep at the point of infiltration, is blocked using a 12-mm, 26-gauge needle with a perpendicular approach. The bony landmarks to be considered while performing the injection in the *Nadbath block* have been stated clearly.[4] However, there is no information about the localization and angular differences of SF in the original study. In ophthalmology textbooks that explain the Nadbath block technique, the application site is explained only superficially, and no morphometric or angular data are provided.[3,6,14] In case reports that describe the complications arising from the Nadbath block, there is no detailed methodological explanation,[9,15–18] probably due to insufficient morphometric data.

SF is a guide and a key bony structure for identifying the facial nerve. The localization of SF must be considered carefully during implementation. There is only one study in the literature that has investigated the morphometric and topographic characteristics of SF on dry bones.[19] Sharma and Varshney[19] examined SF localizations on dry human skulls in the Indian population according to Line 1. They determined that the SF was located anterior to Line 1 at a rate of 83.51%, just over Line 1 at a rate of 13.4%, and posterior to Line 1 at a rate of 3.09%.[12] While Line 1 passes through the SF, most of SF may be localized behind this line. This may lead to errors in nerve blockade. The most lateral end of SF (SF1) forms a precise lateral boundary for the facial nerve to not be harmed. For this reason, a classification that is to be made by defining SF1 based on Line 1 can be a safer approach for a precise Nadbath application. In this study, SF1 was determined as the reference point, and the classification was made based on the topographic placement of this point in reference to Line 1. Mostly frequently, SF1 was located anterior (Type 1 54.7%) to Line 1 in this study. In addition, the

Table 3 The angular values on inferior and lateral aspects in Type 1, Type 2, and Type 3

	Inferior aspect		Lateral aspect	
	(Angle 1) (mean ± SD)	(Angle 2) (mean ± SD)	(Angle 3) (mean ± SD)	(Angle 4) (mean ± SD)
Type 1 ($n = 29$)	11.16 ± 8.14	32.26 ± 2.04	69.09 ± 19.12	54.74 ± 12.31
Type 2 ($n = 18$)	13.55 ± 6.17	14.39 ± 2.25	102.14 ± 7.02	69.02 ± 7.87
Type 3 ($n = 6$)	0.00	23.48 (17.87–51.59)[a]	90.00	64.76 (43.67–72.37)[a]

Abbreviation: SD, standard deviation.
[a]Because of the small sample or nonnormal distribution of data in the Type 3 group, data were presented as the median and range.

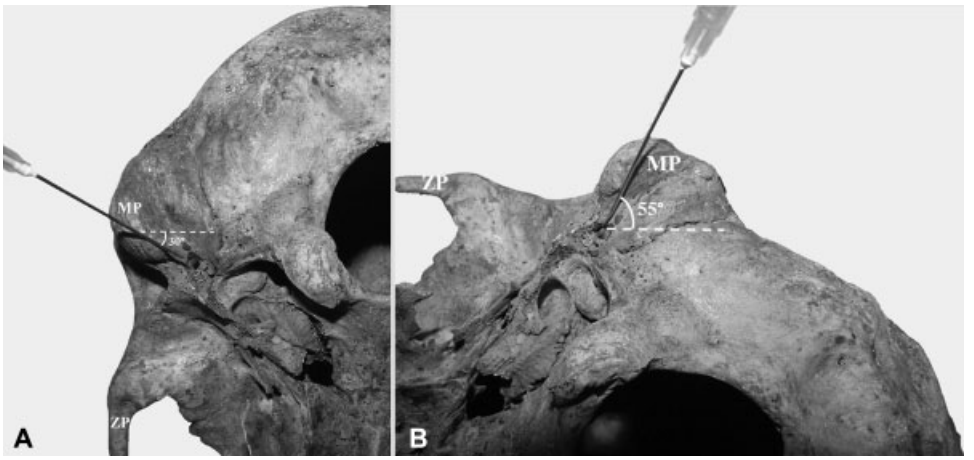

Fig. 4 The recommended angles on transverse and sagittal plane and in Type 1 when the tip of the mastoid process is considered for Nadbath block. (**A**) The needle pushed forward at 30-degree angle on transverse plane with a lateromedial direction. (**B**) The needle pushed forward at 55-degree angle on sagittal plane with a posteroanterior direction.

posterior localization of SF1 in reference to Line 1 (Type 2) should also be considered while performing a Nadbath block.

In addition to topographic features, defining the angular characteristics of the SF allows a more precise description of the Nadbath technique. Sharma and Varshney[19] determined that the center of SF showed a medial–anterior placement by an angle of 66.4 degrees when the anterioposterior line passing through the tip of MP was taken as a basis in the transverse plane. However, they did not present any angular data regarding the placement of SF according to the other landmarks and planes. In this study, angular differences were detected between different types depending on topographic variations. The most lateral end of the SF (SF1) had an anteromedial placement in Type 1 and a posteromedial placement in Type 2 in reference to Line 1 on the inferior aspect. On this aspect, Type 3 was exactly on Line 1. On this aspect, Angle 2 was anterior to Line 3 in all types.

On lateral aspect, point X had an anterosuperior placement in Type 1 and a posterosuperior placement in Type 2 when Line 5 and Line 6 were taken as the basis. In Type 3, SF1 was localized exactly on the perpendicular line passing through point A (Angle 3 was 90 degrees). Points A and B could serve as reference points in the Nadbath block application. When point A is considered as a reference point, the needle should be inserted into the SF at an anterior angle of 11 degrees in Type 1, at a posterior angle of 13 to 14 degrees in Type 2, and vertically in Type 3 on the horizontal plane. A sagittal angular maneuver is impossible because of the limitation imposed by the tympanic part of the temporal bone when point A is taken as the basis. The recommended angles are 30 degrees on the horizontal plane and 55 degrees on the sagittal plane for the most common type (Type 1) when point B is considered (►**Fig. 4**). For Type 2, the recommended angles are 15 and 70 degrees on the horizontal and sagittal planes, respectively. We believe that these results could be beneficial in guiding Nadbath block maneuvers and allow more precise implementation.

The morphometric distance of the SF to bone landmarks is also important, especially for deciding on the gauge of the needle to be used in practice and decreasing potential complication risks. It was reported that the selection of an unsuitable needle could create complications in the neural structures that pass through the jugular foramen.[8,15] In the literature, respiratory complications linked to neural damage were reported when 16-[8,20,21] and 12.7-mm[15] length needles were used after the Nadbath block. Nadbath and Rehmani[4] stated that the depth of the facial nerve was 15 mm from the skin surface, and they recommended using a 12-mm needle while performing the block. In the Indian population, the morphometric distance between point (A) and central point of SF was found as 10.22 and 10.38 mm for the right and left sides, respectively.[19] In this study, the mean distance between SF1 and point (A) was below 10 mm. The morphometric distances between SF and bony landmarks should be taken into consideration in selecting the needle for the Nadbath block to minimize possible complications.

Conclusion

In conclusion, it was determined that the most lateral end of the SF had three different topological placement types when Line 1 was used as a reference. There were angular differences between these SF types on the inferior and lateral surfaces. The recommended angles of application are 30 degrees on the horizontal plane and 55 degrees on the sagittal plane for Type 1 when point B is considered. A needle length below 10 mm is more suitable to minimize the potential complications linked to the nerve block. Knowing the topographic, angular, and morphometric properties of the SF will allow more precise application of Nadbath blocks and reduce the risk of complications.

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None.

Conflict of Interest
None declared.

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